

DESIGN OF
PEORIA - GALESBURG, ELECTRIC RAILWAY

BY

J. A. PASZKIEWICZ
E. L. HOFFMAN

ARMOUR INSTITUTE OF TECHNOLOGY

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Design of the Peoria -

Galesburg electric RY.

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DESIGN
OF THE
PEORIA - GALESBURG ELECTRIC RY.

A THESIS

PRESENTED BY

Joseph A. Paszkiewicz
and
E. Louis Hoffman

TO THE

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DESIGN OF THE
PEORIA-GALESBURG ELECTRIC RAILWAY

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PREFACE

This thesis will consist of two parts. Part A. dealing with the preliminaries, constituting by themselves a statistical and observational report which will show whether the relations between probable revenue and probable cost are such as will probably produce a proper return upon the investment, whether the enterprise is worth expending the considerable amount of money which will be required for the subsequent engineering work.

Part B. will contain the final determinations and specifications of the main engineering features of the project.

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PART A

PRELIMINARIES.

1. GENERAL

This thesis will be based on alignment and grades shown by maps and profile, which we were permitted to use by the projectors of the Peoria, Canton and Galesburg Electric Railway. Recommendations for such type of road and equipment as will be found best suited will be made, -- together with preliminary estimates of probable cost and earning power.

This work will be put in the form of an engineer's report, but methods by which results were determined will be clearly indicated and discussed.

2. PROJECT

The project contemplates the construction of a high-speed interurban electric railway from Peoria in Peoria County, Illinois, via. Farmington County, to Galesburg, Knox County. The distance between Peoria and Galesburg is 50 miles. The project will traverse the following centers of population: Maxwell, Eden, Trivah, Cramers, Farmington, Uniontown, Maquon, Gilson,

Knoxville and East Galesburg. The general location of the project is shown on Sheet #1.

3. RIGHT OF WAY

The project will be located on a private right of way, except in the cities of Peoria and Galesburg where use of the street railway-tracks will be made.

4. TERMINALS

1. PRIMARY TERMINAL

From a traffic standpoint the primary terminal of the project is Peoria. Its growth has been steady and rapid, as will be seen from the curve on Sheet #2 plotted from the U. S. Census statistics up to 1910. The population in 1914, according to the city directory of Peoria, is 89,500, -- approaching closely that which would be found by extending the curve.

Peoria, the second city of Illinois, is an important commercial and manufacturing center. It is situated on the Illinois River which will in time become a portion of the "Great Lakes to Gulf" waterway. It is the county seat of Peoria County.

Institutions of great commercial importance are: Keystone Steel and Wire Co., Jobst and Bethard, the Wilson Grocery Co. and Oakford and Fahnestock, wholesale grocers; The Kingman Plow Co., Clarke Bros., The Woolner Co. and the Corning Co., distillers, -- and a great number of other industries.

Furthermore, Peoria is known as a convention city, as will be seen from the fact that from June, (1913) to January, (1914) eight conventions had been held. Points of historic interest which also would help to produce traffic, are: the Site of the Lincoln - Douglas Debate; Indian Lookout Point; Site of Fort Clark and that of Fort Creve Coeur, the Landing Place of Marquette, Joliet and La Salle, -- and other points of just as much interest.

2. SECONDARY TERMINAL

Galesburg, the secondary terminal, is the county seat of Knox County. Its population according to the city directory is (in 1914) 25,000. Its growth, like that of the primary terminal, has been rapid, -- as will be seen from the curve on sheet #3. It is situated on the main lines of the Chicago, Burlington and Quincy and the Atchison Topeka and Santa Fe Railroads, and is one of the most important division -- points on the former, which has here large shops and freight classification yards; its tie-treating plant located here, is the largest in the country.

Among the important industries are: The Purington Paving Brick Works, claimed to be the largest in the world; The Frost Mfg. Co., making boilers, engines, etc.; The Johnson Refinery Co.; The Wenzelman Mfg. Co., making agricultural implements; the Jordan Co. and the Galesburg Grocery Co., big wholesale grocers; National Biscuit Co., covering the territory comprising Knox, Warren, Mercer and Henderson Counties; Sinclair Bros., shipping great amounts of ice-cream and soft drinks over a radius of 70 miles.

A notable characteristic of both Peoria and Galesburg, is the fine character of their public buildings, churches, schools, railroad stations, etc.

5. TERMINAL FACILITIES

The route of the project in Peoria is shown on Sheet #4. A new terminal is now under construction for the Illinois Fraction System, at Hamilton and Jefferson Sts.; rights to use this terminal could be secured. The



length of the line here is 3.17 miles.

Sheet #5 shows the route in Galesburg where the length of the line is 1.9 miles.

6. POPULATION

With the exception of the coal-mining industry, the territory traversed is a strictly agricultural one.

The predominant item in the revenue account of electric interurban railways is passenger revenue. In the present stage of development of such lines, with their limited operations in the express and freight fields, all the items composing revenue from transportation are of little consequence compared with passenger revenue. It follows logically that the character of the population served by such lines has a distinct bearing upon operating revenue. Therefore, an analysis of the population into its characteristic components is a quite necessary step in establishing the details of this relationship.

The population served by an electric interurban railway may be divided as follows:

primary terminal population, secondary terminal population, and the intermediate or tributary population. The density of the tributary population in the case of the project was determined by approximating its aggregate within one mile on each side of the line, in spite of the fact that this method is rather crude because many local conditions may influence the extent of the zone limiting the tributary population. There is always a possibility in any such problem that the assumption of uniform distribution of the township population will prove to be incorrect. Nevertheless, this method was used since more accurate data could not be obtained.

Determination of Tributary Population

PEORIA COUNTY

Total population (1910) -----	100,255
Land Area, sq. m. -----	636
Population per sq. m. -----	157.6
Rural population per sq. m. -----	48.2
% Rural Population -----	30.56
% Urban Population -----	69.44
Number of farms -----	2717

Townships

	Population in 1910		Area (sq. m.)
Kickapoo -----	1376	----	7.2227
Limestone ----- (Maxwell)	6147	----	7.2227
Logan ----- (Eden - Hanna City)	1374	----	7.2227
Trivoli ----- (Cramers - Trivoli)	924	----	7.3006

KNOX COUNTY

Total population (1910) -----	46,159
Land Area, sq. m. -----	717
Population per sq. m. -----	64.9
Rural population per sq. m. -----	33.9
% Rural population -----	52.15
% Urban population -----	47.85
Number of farms -----	2,860.

Townships

	Population (1910)		Area (sq. m.)
Haw Creek ----- (Gilson)	826	----	9.766
Knox ----- (Knoxville)	3263	----	9.766
Maquon ----- (Maquon)	1187	----	9.668

FULTON COUNTY

Total population (1910) -----	49,549
-------------------------------	--------

Land Area, sq. m. -----	884
Population per sq. m. -----	56.1
Rural population per sq. m. -----	44.2
% Rural population -----	78.91
% Urban population -----	21.09
Number of farms -----	5200

Townships

	Population (1910)	Area (sq. m.)
Farmington ----- (Farmington)	4723	6.094

The portion of the intermediate population which may be considered as tributary to the line, was taken as the population of a strip of territory one mile in width on each side of the project. To determine the population of such a strip it was assumed that the townships through which the road extends was evenly populated. The tributary population was then found from the proportion.

$$\frac{\text{Tributary population}}{\text{Township population}} = \frac{\text{Area of strip}}{\text{Area of township}}$$

The township population was obtained from the census reports and estimated, and the required areas were scaled from topographical maps.

TRIBUTARY POPULATION

		Per mile
Farmington township---	$\frac{4723 \times 2}{6.094}$	-- 1000 (assumed)
Haw Creek Township ---	$\frac{826 \times 2}{9.766}$	-- 169
Knox Township -----	$\frac{3263 \times 2}{9.766}$	-- 668
Maquon Township -----	$\frac{1187 \times 2}{9.668}$	-- 245
Limestone Township ---	$\frac{6147 \times 2}{7.223}$	-- 1700
Logan Township -----	$\frac{1374 \times 2}{7.223}$	-- 380
Trivoli Township -----	$\frac{924 \times 2}{7.4}$	-- 250
Peoria Township -----	(estimated)-	1700

LENGTH OF THE INTERURBAN PART OF THE LINE

	Miles
Peoria - Hanna City -----	8.43
Hanna City - Eden -----	1.99
Eden - Trivoli -----	2.74
Trivoli - Cramers -----	3.22
Cramers - Farmington -----	2.65
Farmington - Uniontown -----	6.637
Uniontown - Maquon - Gilson -----	9.85
Gilson - Knoxville -----	5.3
Knoxville - E. Galesburg - Galesburg --	<u>5.02</u>
Total -----	45.84

The tributary population per mile multiplied by the length of the line through the respective townships will give the total tributary population.

Peoria - Hanna City	----	8.43 x 1700	---	14,331
Hanna City - Eden	-----	1.99 x 380	---	756
Eden - Trivoli	-----	2.74 x 380	---	1,045
Trivoli - Cramers	-----	3.22 x 250	---	805
Cramers - Farmington	---	2.65 x 250	---	663
Farmington - Uniontown	-	6.637 x 1000	--	6,637
Uniontown - Gilson	-----	9.85 x 245	----	2,413
Gilson - Knoxville	-----	5.3 x 169	----	896
Knoxville - Galesburg	--	5.02 x 668	----	<u>3,353</u>
Tributary population				30,899
per mile				674

The resulting tributary population of 647 per mile is a very favorable figure compared with that of similar roads.

Mr. L. E. Fisher⁶ (Elec. Ry. Jour. 8/23/13) in determining the tributary population excludes the tributary farming population on the ground that in a normal territory the value of the farming population from the viewpoint of its traffic productiveness is reflected in the size and character of the towns and villages. If such a territory has fertile lands it will support a greater town population, and if the roads are good in a farming community

the sphere of the commercial activities of the town will be increased and a larger population will result. The logic of this reasoning is apparent. In the case of the project, however, the elimination of the tributary farming population is difficult to effect, since it was impossible to obtain exact information relating to the density of this farming population, -- the U. S. Census statistics failing to furnish such data. However, they do give the number of farms in each of the countries traversed. Assuming five possible users of the line per family and knowing the area of the county in square miles, we can determine the farming population per sq. m., on the assumption, again, that this farming population is uniformly distributed; also the length of route in each county being known, the tributary farming population in each of the three counties is found. Deducting this tributary farming population from the total tributary population determined above, will give the intermediate town and village population.

PEORIA COUNTY

Number of farmers in county -----	2717
Number of possible users of line -----	13585
Number of sq. m. in county -----	636
Farming population per sq. m. $\frac{13,585}{636}$	21.4
Length of line in Protia Tp.-----	8.43 m.
Farming population $8.43 \times 21.4 \times 2$ ----	360.8
Length of line in Logan Tp. -----	4.73 m.
Tributary population $4.73 \times 21.4 \times 2$ ---	202.4
Length of line in Trivah Tp. -----	5.87 m.
Farming population $5.87 \times 21.4 \times 2$ ----	251.2

KNOX COUNTY

Number of farmers -----	2,860
Possible users -----	14,300
Number of sq. m. in county -----	717
Farming population per sq. m. -----	20
Length of line in Maquon Tp. -----	9.85 m.
Farming population $9.85 \times 20 \times 2$ ----	394
Length of line in Haw Creek Tp. -----	5.3 m.
Farming population $5.3 \times 20 \times 2$ ----	212
Length of line in Knox Tp. -----	5.02 m.
Farming population $5.02 \times 20 \times 2$ ----	200.8

FULTON COUNTY

Number of farmers -----	5,200
Possible users -----	26,000
Number of sq. m. in county	884
Farming population per sq. m.	29.4
Length of line in Farmington Tp.	6.637 m.
Farming population $6.637 \times 29.4 \times 2$ -----	390.3
Total Farming population ----	2,012
With allowance for error ----	2,100
Total Tributary Population -----	30,899
Tributary Farming Population -----	2,100
<u>Intermediate town and village</u>	<u>28,800</u>
<u>population</u>	
Per mile	628

A portion of the population of Galesburg could be included in that of the tributary population on account of the fact that Peoria is on the main line of several large railroad systems which do not touch Galesburg that Galesburg is on the main line of the Santa Fe which does not reach Peoria, and that the secondary terminal is on the main line of the C. B. & Q. which gives over a branch line a poor and very infrequent service between these terminals. Considerable interchange of passenger traffic

between the different railway systems is to be expected and under these conditions more traffic will originate in the primary terminal than is usually the case.

7. FEEDER LINES

(1) Peoria

The steam roads touching Peoria are: Chicago & Northwestern; C. & A.; C. R. I. & P.; Lake Erie & Western; Peoria & Pekin Union; Toledo, Peoria & Western; Chicago, Peoria & St. Louis; Minneapolis & St. Louis; Big Four; C. B. & Q. Electric roads having their terminals in Peoria are: Illinois Traction System (connecting with Bloomington, Champaign, Danville, Decatur, Springfield and St. Louis), and the Peoria Railway Terminal (connecting with Bartonville, Hollis and Pekin).

(2) Galesburg

The Santa Fe and the C. B. & Q. Railroads will be the steam railway feeders. Electric feeder lines will be the Peoples Traction Co., operating an interurban line between Galesburg and Abingdon, and the Rock Island Southern R. R., connecting with Monmouth, Rock Island, Moline and Davenport.

(3) Farmington

Two steam roads will feed into the project, -- the C. B. & Q. and the Minneapolis & St. Louis. Branch lines from Lewistown, Canton and Fairview will feed at Farmington.

8. COMPETITION

The only steam competition to the project is that offered by the C. B. & Q. The road operates three trains daily each way requiring from 1 hour, 33 minutes to 1 hour, 55 minutes for the trip. The following is a schedule of trains showing time of arrival and departure at terminals, and time of trips:

LEAVE GALESBURG	ARRIVE PEORIA	TIME OF TRIP	
		Hr.	Min.
A. M. 4:40 -----	A. M. 6:25	1	50
10:20 -----	P. M. 12:10	1	50
P. M. 4:55 -----	6:45	1	45

LEAVE PEORIA	ARRIVE GALESBURG	TIME OF TRIP	
		Hr.	Min.
A. M. 7:05 -----	A. M. 8:55	1	50
P. M. 3:00 -----	P. M. 4:55	1	55
7:10 -----	8:43	1	33

The distance between city-limits of Galesburg and Peoria is 45.84 miles. The project

could readily equal the average time of the C. B. & Q. Considering the comparative frequency of service by the interurban and the steam road, and also the fact that the terminals of the project are much nearer the business centers of the cities, the effect of the steam competition should be relatively small.

There is no electric competition to the project.

9. OPERATION

For the greater part of the day an approximately hourly schedule is assumed for passenger service. The car selected will contain a baggage compartment which will enable the handling of package freight and other small freight, such as dairy products, eggs, etc.

10. CONSTRUCTIVE FEATURES

(1) ALIGNMENT AND GRADES.

Conditions of alignment and grades are favorable throughout. In Galesburg there are 2 curves and a loop, making additional 4 curves. In Peoria, there are 4 curves.

On the interurban portion of the line the maximum curvature is 30,deg., or 1910 ft. radius. The maximum grade is 2% including city trackage. Of the interurban portion, 18.4% will be tangent and of this 6.8% will be tangent over trestles.

(2) GRADING

The profile shows a few grades greater than 2%; these will cut or filled to make 2% grades.

(3) RAILROAD CROSSINGS

According to the profile there will be three crossings of steam roads, viz., over the C. B. & Q. spur about 1.2 miles from Galesburg; the C. B. & Q. main line about 3 miles from Galesburg and the C. B. & Q. and Iowa Central at Farmington.

(4) BRIDGES

One steel bridge, 300 ft. long will be erected across Spoon River, and one, 500 ft. long, across Kikapoo Creek.

(5) TRACK

For main track construction, 7015, A. S. C. E. standard "T" rails are assumed laid



on ties spaced 2640 per mile.

(a) BALLAST

Ballast is just as essential to the riding qualities of good track as good rails and ties. Poor riding track which is so due to poor ballast conditions introduces stresses into a car body which eventually will loosen nearly every joint of the structure. Hence, besides regular ballast, a cushion for the latter is contemplated. It will consist of 1 ft. of gravel; this, with an additional 1 ft. of broken stone will give excellent track.

(6) OVERHEAD LINE

The transmission voltage will be, probably, 33,000; direct current distribution is contemplated.

(7) POWER HOUSE AND SUBSTATIONS

Should the erection of a power plant be found advisable or necessary it will be located at Spoon River. This point should be selected on account of the nearness of the desirable water supply for the feed water and condensing apparatus, and the convenience and saving attained by depositing

the fuel in the bunkers directly from the coal barges. Only one independent substation will then be required, the power house acting as another substation. The extra substation would probably be located between Trivoli and Eden.

(8) ROLLING STOCK

Motor passenger cars are assumed, with smoking and baggage compartments, and equipped with 4-600-volt. motors and with multiple control. The car with equipment and passengers (the latter at 140 lb.) will weigh 45 tons.

(9) BUILDINGS:

A building will either be purchased or erected in Galesburg to be used as a terminal. In addition, a number of smaller stations and platforms will be needed along the line. An inspection shed, and a painting and repair shop will further be built. The repair shop will be adequate for all minor repairs. It is assumed that flange-turning and heavy repair work will be let out, as there are extensive railway shops in Galesburg.

11. PRELIMINARY DETERMINATION OF SCHEDULES AND EQUIPMENT

1. SCHEDULE

As stated before the project is to give approximately hourly service.

Reconnaissance showed no accurate data as to the distribution of the numbers of passengers to be carried. However, it was seen from the traffic on the C. B. & Q. between terminals, that the bulk of the business is done during the few hours of the morning and the evening, -- as would be expected.

The schedule is plotted with time of day in hours and minutes as ordinates and distances in miles as abscissae. After the scales of coordinates have been determined, a series of slanting lines are drawn to represent the progress of the car from station to station. This chart is sufficiently accurate for a preliminary study of traffic possibilities, power requirements, etc. It is shown on Sheet #7. The time assumed was 1 hour 45 minutes, cars running hourly

from 5 A. M. to 7 A. M., from 5 P. M. to 8 P. M. and at 2 hour intervals from 7 A. M. to 5 P. M. the last car leaving either terminal at 11 P. M. It will be seen from the chart that 7 cars could in an extremity perform the service. However, an additional 3 cars were assumed, making a total of ten.

<u>PEORIA TO GALESBURG</u>				<u>GALESBURG TO PEORIA</u>			
A. M.	(1)	5:00 ---	6:45	(1)	5:00 ---	6:45	
	(2)	6:00 ---	7:45	(4)	6:00 ---	7:45	
	(3)	7:00 ---	8:45	(7)	7:00 ---	8:45	
	(4)	9:00 ---	10:45	(1)	9:00 ---	10:45	
	(5)	11:00 ---	12:45	(2)	11:00 ---	12:45	
P. M.	(1)	1:00 ---	2:45	(3)	1:00 ---	2:45	
	(2)	3:00 ---	4:45	(4)	3:00 ---	4:45	
	(3)	5:00 ---	6:45	(1)	5:00 ---	6:45	
	(4)	6:00 ---	7:45	(2)	6:00 ---	7:45	
	(6)	7:00 ---	8:45	(5)	7:00 ---	8:45	
	(7)	8:00 ---	9:45	(3)	8:00 ---	9:45	
	(1)	11:00 ---	12:45	(6)	11:00 ---	12:45	

Car #1	remains	in	Galesburg
" #2	"	"	Peoria
" #3	"	"	"
" #4	"	"	Galesburg
" #5	"	"	Peoria
" #6	"	"	"
" #7	"	"	Galesburg

As a second step, the line was assumed to be straight and level and the stations or steps at equal distances apart. In this way the length of the average run was found to be 19,500 ft.

WEIGHT TO BE ACCELERATED

Weight of car body, equipment, etc. 80,000#

Seating capacity 62

Weight of average passenger load

$$62 \times 140 = \frac{8,680\#}{88,680\#}$$

Total weight

Assume it to be 45 tons.

TRAIN RESISTANCE

Let W = Weight of car,

V. speed in miles per hour (assumed schedule)

a. Cross-sectional area of front of car in sq. ft.

Then the following empirical formula gives the total train resistance in pounds per ton weight of car,-

$$F = \frac{50}{\sqrt{W}} + .03V + \frac{.002V^2}{W} \cdot a$$

With speed taken at 41 m.p.h., and area equal to $(9 \times 11\frac{1}{2}) = 104$ sq. ft. from dimensions shown by drawing (of car selected) on Sheet #8, the total train resistance was found to be 16.2 pounds per ton.

From the curves for a single car by A. H. Armstrong, by interpolating for a 45-ton car, the value of the train resistance was found to be 18.25 pounds per ton. Taking a mean of these two the total train resistance per ton is 17.2 pounds. Sheet #9 shows the curve of train resistance for a 45-ton car.

PRELIMINARY SPEED-TIME CURVE

By the use of the method given by C. T. Hutchinson the best acceleration rate was found to be 1.5 miles per hour per second, with a duration of stop of 30 seconds. The braking rate was taken as 1.5 m. per hr. per sec. With the above rate of acceleration the energy input was found to be 61 watt-hours per ton mile, and the motor capacity 9.8 hp. per ton weight.

Motor G. E. - 66 - A. - 9 of 125 hp. at 208 amperes and 500 volts was taken to be best suited. Several gear ratios were tried out, and the ratio of pinion 29 to gear 60 ($= 2.07$) was decided on for trial on the speed-time curve.

If W = total mass accelerated in tons,

a = acceleration in m.p. h. p. s.,

w = weight in tons plus 10% for rotational inertia,

t = Tractine effort in pounds due to train resistance,

then $T = (91.1 a W) + t W = 7799 \text{ lb. or } 1950 \text{ lb.}$
per motor.

From the curves showing the operating characteristics of this motor, shown on Sheet #10, a tractine effort of 1950 lb. will be exerted at 25.5 miles per hour when a current of 223 amperes will be taken.

The various acceleration rates for the speed-time curve were calculated both by the formula $a = \frac{T - tW}{100 W}$ and by the "differential" method using the expression $a = \frac{dv}{dt}$

From the preliminary speed-time curve shown on Sheet #11 it is seen that the average run of 19,500 ft. can be made in 306 seconds; the accelerating, coasting, and braking periods are respectively, 166 sec., 121 sec., and 19 sec. The maximum speed reached is 51 miles per hour.

2. EQUIPMENT

CURRENT CURVE

The current curve on Sheet #11 was plotted in terms of amperes per car. The periods when the motors are in series and in parallel are shown.

VOLTAGE CURVE

The voltage curve was next plotted, starting at the voltage which is required to overcome the ohmic resistance of the motor with 217 amperes flowing; using 0.35 ohm as the resistance gave an $R'I$ drop of 76 volts for the initial voltage value. As the resistance is cut out, the voltage rises till it reaches 600 volts, where it remains until the power is cut off.

ROOT SQUARE CURRENT CURVE

The current which, when flowing continuously, will give the same average loss, will be the square root of the average of the squares; i. e., the equivalent heating current is the square root of the mean square current. Dividing the sum of these squares by the total number of seconds in the cycle ($306 + 30$), and

extracting the square root of the quotient, there results the equivalent heating current of 72 amperes. The average voltage was found to be 308 volts. These results were compared with those given for the #89 Westinghouse Motor, which has a maximum capacity of 105 hp. at 400 volts. The motor under consideration is volted at 125 hp. and takes approximately the same current as the above Westinghouse motor. It will, therefore, be fair to conclude that this trial motor will not be over heated.

The results thus found could not be checked by determining the losses since no loss data for this motor could be obtained either by reference to technical literature or by application to the manufacturers (General Electric Co.).

12. PROBABLE OPERATING REVENUE

The project under consideration will be a normal railway. The general characteristics of such a railway are: (a) private right-of-way outside of cities and villages; (b) entrance into cities and towns over streets secured by franchises; (c) ample and modern car equipment; (d) roadbed with reasonable grades and curves;

(e) substantially hourly service, with schedule practically equal to that of the competing steam-railway lines; (f) handling of package freight, and (g) a rate of fare approximately 2 cents per mile.

As stated above, the chief item in the revenue account of an electric railway is that of passenger revenue. Hence, other items which could be considered in the case of the project, such as, baggage revenue, mail revenue, express revenue and milk revenue, also revenue from advertising and the sale of power, will not be taken up in the preliminary determination of probable revenue.

Extensive statistics support the conclusion that approximately the operating revenue varies directly with the aggregate of the intermediate town and village population. Referring to the curves drawn by Mr. Fischer, and representing the relation between the earnings of 36 interurban roads and the town and village population, it is seen that the average is shown by a line indicating \$10.. per capital of intermediate town and village population. See Sheet # 6.



By earnings here is meant the operating revenue from intercommunication of primary terminal and intermediate population and from the intercommunication of intermediate population centers only.

Because both the primary and secondary terminals are important manufacturing centers, and the former also an important railroad center, there will be the average cause for intercommunication.

From Mr. Fischer's statistics it is seen that where the distance between terminals is 40 miles or less, the revenue from the intercommunication of (1) the population of the secondary terminal and the intermediate population and (2) the population of the primary terminal and that of the secondary terminal, -- will be a minimum of \$6. per capita of that secondary terminal population; also that when the distance between terminals is greater than 40 miles, this revenue will be diminished practically 1% for each mile increase. In the present case, the distance between terminals is 46.58 miles. Hence, the reduction in the secondary revenue will be 6.58%, i. e. a reduction of \$.40 per capita, which gives \$5.60 per capita.



As determined in Section 6, the intermediate town and village population is 28,800.

Primary Operating Revenue

28,800 Intermediate population at \$10. per
capita, \$288,000

Secondary Operating Revenue

23,000 Secondary terminal population at \$5.60

	per capita	<u>\$128,800</u>
Total Gross Reven.		\$416,800
per mile		8,015.

13. PROBABLE OPERATING EXPENSE

1. Way and Structures

Approximately \$832. per mile-track/
year---- \$832.

2. Equipment and Depreciation

Approximately \$500 per mile-track/
year---- \$500.

3. Traffic

Approximately \$100 per mile/ year-- 100.

4. Conducting Transportation

Approximately \$1600. per mile/
year ---- 1600.

5. General and Miscellaneous

Approximately \$650 per mile/
year ---- 650.

Total Operating Expenses/
mile ----\$3682.

Taxes - per mile ----- 318.

The first account, way and structures, takes in the following details: superintendence of way and structures, maintenance of roadway and maintenance of track.

The second or the equipment account includes: superintendence of equipment, maintenance of power-plant and substation equipment; maintenance of cars; maintenance of electric equipment of cars; equipment expenses connected with shop machinery and tools; and the depreciation of equipment.

The traffic account includes advertising and superintendence.

The account under the heading "conducting transportation," includes: superintendence of transportation; all costs connected with the generation of power and the operation of cars.

The fifth account includes: salaries and expenses of the general office force; legal expenses; insurance; rent of tracks and terminal.

Taxes vary on different roads in different states. In Illinois, the average of various roads reaches \$318. per mile of track.

The statistics compiled by Mr. L. E. Fischer were used in this approximation of operating costs.

14. ESTIMATED COST

The following is an estimate of the cost of construction and equipment based on data compiled by Prof. Nichols (A. I. T.) and on Gillette's "Cost Data."

1. ROAD-BED

Per mile of route. Single Track.

(a) Material.

Track -----	110 tons, 70#, "T" rail	\$30.---	3300
Ties -----	2640	0.50	1320
Spikers, Bolts, Nuts, Plates, Bonds, etc.	800		
2000 cu. yd. Ballast -----	0.80	1600	
Bridges, abutments, culverts -----		1000	
Total Material-----			<u>\$8120</u>

(b) LABOR

Excavation and embankments -----	\$1,500.
Bridges, abutments, culverts -----	500
Laying of Track -----	700
Bonding, etc.-----	300
Teaming material -----	250
Total Labor -----	<u>3,250</u>

Total material and Labor --- 11,370

Engineering and Superintendence 10 % 1,137

Total ----- 12,507

For double track ----- \$25,014

2 OVERHEAD LINE

Trolley with Bracket Construction, 130 ft. span.

(a) Material

88 - 35 ft. wooden poles	-----\$5.50	-----\$484.00
44 - 2 pin arms	-----0.45	-----19.80
88 - Arm Braces, etc.	-----0.60	-----52.80
88 - Feeder Insulators and pins	.45	-----39.60
88 - Strain Insulators & pins	---.50	-----44.00
2500 ft., 1/4" Steel wire, 288#	.08	-----23.04
88 - Trolley Suspensions	-----.80	-----70.40
88 - Trolley ears	-----0.20	-----17.60
8 - Strain ears	-----0.60	-----4.80
8 - Feeder ears	-----0.50	-----4.00
4 - Splicing Sleeves	-----1.75	-----7.00
2 Lightning arresters	-----12.50	-----25.
20 Anchor rods	-----1.80	-----36.
10,800 ft. 4/0 Trolley, 6,800#	0.80	-----1700.
3,000 ft. 5/16" Steel strand		
Cable 630 #	0.80	-----50.40
88 Eye-bolts nuts for cable		
spans	0.20	-----17.60
Total Material	-----	<u>\$2596.04</u>

(b) LABOR

Distribution and erection of 88 poles	\$5.00	\$440.
Stringing of trolley	-----	60.
Incidentals	-----	60.
Total Labor	-----	<u>\$560.</u>
Total Material and Labor		3,156.04
Engineering and Superintendence 10%	-----	315.60
-33-	Total	<u>\$3,471.64</u>

Additional to (2) for

3 - Phase Transmission Line on Same Poles.

44 - 40 ft. Poles, additional price	\$2.00	\$88.00
44 - 4 Pin Cross-arms -----	1.10	48.40
88 - Cross-arm braces -----	0.70	61.60
140 - 33,000 volt Insulators -----	0.70	98.00
140 - 33,000 " Insulator pins --	0.50	70.00
16,500 ft., #2 Copper wire 6650# --	0.25	1,662.50
5400 ft., 1/4" Steel ground cable, 621#	0.08	49.68
500 ft. #8 B. & S. Copper wire for ground connections 25#	0.25	6.25
Stringing high-tension conductor and ground wire -----		120.00
Total -----		\$2,204.43
Engineering and Superintendence 10% ----		220.44
Total -----		\$2,424.87

POWER STATION

Building -----	20,000
Equipment { steam { electric } --	<u>100,000.</u> 120,000.
Engineering and Supertendence 10% ----	12,000.
Total ---	\$132,000.
Per mile -----	\$2,538.50

SUBSTATIONS

3 Buildings -----	6,000.
7 Syn. Converters ----	20,000.
Step-down Transformers	12,000.
3 Switchboards -----	6,000.
Wiring -----	3,000.
Total	<u>47,000</u>
Eng'g and Superintendence	
10% --	<u>4,700.</u>
Total	<u>51,700</u>

Per mile ----- \$994.23

WAITING-ROOMS, PLATFORMS, ETC:

Terminal Building in Galesburg	\$35,000.
Waiting-rooms, platforms, etc.	<u>10,000</u>
	<u>\$45,000.</u>
Eng'g and Superintendence 10%	<u>4,500.</u>
Total -----	<u>\$49,500.</u>
Per mile ----	\$952.
Inspection Sheds and shops	15,000.
Eng'g and Superintendence 10%	<u>1,500.</u>
Total	<u>\$16,500.</u>
Per mile	\$311.

ROLLING STOCK

10 motor passenger cars, 100,000	
Snow-plow, Construction	
car, etc.	<u>27,000</u>
	<u>\$127,000.</u>
Eng'g and Superintendence 3%	<u>3,810.</u>
Total	<u>\$130,810.</u>

Per mile ----- \$2,515.20

ESTIMATED COST PER MILE

1. Roadbed -----	\$25,014.00
2. Overhead Line (3,471.64)	5,896.51
Transmission Line(2,424.87)	
3. Power Station -----	2,538.50
4. Substations -----	994.23
5. Waiting-rooms, platforms, etc	952.00
6. Inspection-shed, shop ----	311.00
7. Rolling stock -----	2,515.20
Per mile	<u>\$38,221.44</u>
Total, for 52 miles -----	\$1,987,514.81
Interest, 6% -----	<u>119,250.89</u>
TOTAL ESTIMATED COST-----	\$2,106,765.70

The estimated cost was calculated on the 52 mile basis, to cover possible costs of sidings, turnouts, etc.

15. SUMMARY

Total Gross Revenue -----	\$416,800.
Total Operating Expenses 52 Miles at	
\$36.82 / mile	<u>191,464.</u>
NET EARNINGS -----	\$225,336.
Taxes, 52 miles at \$318 / mile	<u>16,536.</u>
Net Earnings Applicable to Fixed Charges and Surplus -----	\$208,800.
Interest on Construction Cost	
(\$2,106,765.70 at 6%) -----	<u>126,406.</u>
Surplus Earnings Applicable to Dividends ----	\$ 82,394.
Assuming Preferred Stock \$1,000,000.	
Dividends, 6% -----	<u>60,000.</u>
SURPLUS -----	\$ 22,394.



16. CONCLUSIONS

The summary in the preceding section shows that the project is one of the best. All the determinations outlined above were made with somewhat exaggerated costs and a liberal allowance for error etc. against the project. The probable operating revenue of \$8,015 per mile by far exceeds that of most roads similar to the project. The estimated cost of operation and taxes per mile, viz., \$4,000. leaves a good balance.

Additional income will be derived from advertising and the probable future transfer of mail. Milk revenue and the income from other small freight handling will further increase the profits. Briefly, it can be said that without doubt, the project, with good and efficient management, should be one of the best-paying enterprises in the electric railway field.

-B-

FINAL DETERMINATIONS

1. Individual Runs Between Termini

To construct the individual speed-time curves, the grades and curvature were

taken from the profile and the alignment maps respectively.

CORRECTION FOR GRADES AND CURVES

1. Grades

Since in railway work the angles of grade are small, the sines are approximately equal to the tangents, and therefore grades may be expressed as the ratio of the vertical rise to the horizontal length of grade. The tractive effort necessary to move each ton of car weight up a one percent grade is therefore $\frac{1}{100} \times 2000$, or 20 pounds; to draw the car of 45 tons up a grade of q per cent with uniform speed requires

$$G = 20 \times 45 \times q \text{ pounds}$$

tractive effort. For a down grade G is considered negative.

2. CURVES.

Curvature of track presents additional resistance to the motion of a car because of increased flange friction. To neutralize this effect a larger tractive effort must be exerted. Curve resistance was taken as 0.6 pound per ton of train weight per degree of curvature, -- this being an average value.

At curves, the inner rail will not be

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PEORIA LIMITS - MAXWELL

MAXWELL- PEORIA
LIM.

LENGTH FEET	CURVATURE DEGREES	% GRADE UP DOWN	CORREC- TION 15/ton	CORRECTION 25/ton
140		1	.20.	-20.
200	1	1	20.6	-19.4
1,610		1	20	-20
910		2	40	-40
1,120		Level	0	0
390		1.8	-36.	36
<u>3,030</u>		0.63	12.6	-12.6
20,735				

MAXWELL - HANNA CITY

HANNA CITY -
MAXWELL

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
420		0.63	12.6	-12.6
490		0.82	16.4	-16.4
415		0.17	3.4	- 3.4
175	0.5	0.17	3.7	- 3.1
2,450	0.5	0.69	14.1	-13.5
350		0.69	13.8	-13.8
1,000		1.60	32	-32
1,000		0.2	4	- 4
1,000		LEVEL	0	0
2,000		0.6	-12	12

MAXWELL - HANNA CITY

HANNA CITY -
MAXWELL
CORRECTION

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION
875		0.75	15
600	1.5	0.75	15.9
3,025		0.75	15
1,750		0.45	-9
875	1.5	0.45	-8.1
375		0.5	-10.
1,500		0.13	2.6
2,500		0.4	-8
1,000		0.9	18
1,900		0.37	7.4
200	1	0.37	8
425		0.37	7.4
200	1	0.37	8
275		0.37	7.4
375		0.29	5.8

 25,175

EDEN - TRIVOLI

TRIVOLI -
EDEN
CORRECTION

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC TION
L 1,825		LEVEL	0
2,000		0.3	-6
1,800		0.39	-7.8

EDEN - TRIVOLI

TRIVOLI -

EDEN

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
1,200		0.17	3.4	-3.4
2,000		0.55	11	-11
1,600		0.31	-6.2	6.2
1,400		0.71	14.2	-14.2
2,075		0.13	2.6	-2.6
200	2	0.13	3.8	-1.4
125		0.13	2.6	-2.6
175		0.63	12.6	-12.6
200	2	0.63	13.8	-11.4
900		0.63	12.6	-12.6
15,500				

HANNA CITY - EDEN

EDEN -
HANNA CITY

LENGTH	CURVATURE	% GRADE UP DOWN	CORRECTION	CORRECTION
1,200		0.29	5.8	-5.8
200	1	0.29	6.4	-5.2
625		0.29	5.8	-5.8
200	1	0.29	6.4	-5.2
4,400		0.29	5.8	-5.8
1,700		0.88	-17.6	17.6



HANNA CITY - EDEN

EDEN -
HANNA CITY

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
300		LEVEL	0	0
2,000		0.4	8.	-8.
<u>175</u>		LEVEL	0	0
10,800				

TRIVOLI - CRAMERS

CRAMERS -
TRIVOLI

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
325	1	0.63	13.2	-12
950		LEVEL	0	0
200	1	DO	0.6	0.6
1,350		DO	0	0
1,200		0.67	13.4	-13.4
1,800		0.43	-8.6	8.6
2,000		0.1	2	-2
1,000		0.5	10	-10
1,000		0.1	2	-2
1,600		LEVEL	0	0
2,400		0.42	8.4	-8.4
<u>1,925</u>		0.3	-6.	6
15,750				

CRAMERS - BARMINGTON

FARMINGTON -
CRAMERS

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
1,475		0.3	-6	6
1,600		LEVEL	0	0
1,600		0.7	14	-14
1,000		0.3	-6	6
5,000		LEVEL	0	0
1,200		0.21	-4.2	4.2
200	1	0.21	-3.6	4.8
1,000		0.21	-4.2	4.2
1,525		0.38	-7.6	7.6
425	5.7	LEVEL	3.42	3.42
1,175		DO	0	0
175	11.5	DO	6.9	6.9
1,180		0.94	-18.8	18.8
1,050		0.1	-2	2
360		0.28	-5.6	5.6
680		0.44	-8.8	8.8
330		0.91	-18.2	18.2
250		LEVEL	0	0
<u>400</u>		0.75	-15.	15.
20,625				

FARMINGTON - UNIONTOWN

UNIONTOWN -
FARMINGTON

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
450		0.81	16.2	-16.2
C. B. and Q. IOWA CENTRAL				
1,175		0.81	16.2	-16.2
575	10.4	0.81	22.44	- 9.96
270		0.81	16.2	-16.2
1,000		0.2	-4.	4
580		0.54	10.8	-10.8
200	1	0.54	11.4	-10.2
520		0.54	10.8	-10.8
700		0.71	-14.2	14.2
1,100		1.8	-36	36
600		1	-20	20
1,900		LEVEL	0	0
2,400		2 0.58	-11.6	11.6
1,300		2	-40.	40.
700		LEVEL	0	0
900		2	40	-40
600		1.1	22	-22
1,705		0.52	10.4	-10.4
200	2	0.52	11.6	9.2
595		0.52	10.4	-10.4
1,900		1.6	32	-32
2,000		1.5	-30	30
2,700		0.76	-15.2	15.2



FARMINGTON - UNIONTOWN

UNIONTOWN -
FARMINGTON

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
2,005		LEVEL	0	0
1,000		1.5	30	-30
300		LEVEL	0	0
980		1.3	-26	26
<u>3,020</u>		LEVEL	0	0
30,375				



UNIONTOWN - MAQUON

MAQUON -
UNIONTOWN

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
3,100		LEVEL	0	0
400		0.75	-15	15
1,600		0.94	-18.8	18.8
700		0.3	-6	6
175	2	0.69	15	-12.6
1,125		0.69	13.8	-13.8
1,000		LEVEL	0	0
3,000		0.4	-8	8
1,800		0.84	-16.8	16.8
200	2	0.84	-15.6	18
2,400		1.3	-26	26
3,900		LEVEL	0	0
225		1	20	-20

SPOON RIVER

375		1	20	-20
2,780		2	40	-40
700		1	20	-20
325		0.46	9.2	-9.2
300		1	-20	20
340		LEVEL	0	0
100		0.1	2	-2
680		0.74	14.8	-14.8
700		0.25	5	-5
200	3	0.25	6.8	-3.2
1,350		0.11	-2.2	2.2
<u>27,475</u>		-47-		

MAQUON - GILSON

GILSON -
MAQUON

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
2,075		0.11	- 2.2	2.2
200	3	0.11	- 0.4	4
1,500		0.11	- 2.2	2.2
2,300		0.83	16.6	-16.6
3,800		LEVEL	0	0
1,600		0.81	16.2	-16.2
900		0.78	15.6	-15.6
1,000		LEVEL	0	0
800		0.88	-17.6	17.6
1,000		1.5	-30	30
300		LEVEL	0	0
975		1.5	-30	30
530		LEVEL	0	0
1,370		1.5	30	-30
200	1	1.5	30.6	-24.9
1,630		1.5	30	-30
200		1.05	21	-21
990		0.42	8.4	- 8.4
955		0.16	3.2	- 3.2
200	3	0.16	5	- 1.4
550		0.16	3.2	- 3.2

23,075

GILSON - KNOXVILLE

KNOXVILLE -
GILSON

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
255		0.16	-3.2	3.2
2,000		0.15	-3	3
145		1	20	-20
200	3	1	21.8	-18.2
655		1	20	-20
1,100		0.91	-18.2	18.2
800		LEVEL	0	0
595		2	40.	-40.
200	3	2	41.8	-38.2
55		2	40	-40
750		LEVEL	0	0
1,100		2.	-40	40
250		LEVEL	0	0
1,650		2	40	-40
600		1	20	-20
900		LEVEL	0	0
1,700		0.18	3.6	- 3.6
700		0.72	14.4	-14.4
2,950		1.1	22	-22
550		LEVEL	0	0
700		0.86	-15.2	15.2
400		LEVEL	0	0

GILSON - KNOXVILLE

KNOXVILLE -
GILSON

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
700		0.72	-14.4	14.4
900		1.8	-36	36
500		1.2	-24	24
500		1.7	-34	34
300		2.	-40	40
1,200		1.1	22	-22
480		LEVEL	0	0
200	3	DO	1.8	1.8
470		DO	0	0
800		2.	40	-40
300		0.7	14	-14
700		0.43	-8.6	8.6
500		0.2	4	- 4
480		0.3	6	- 6
600		0.83	16.6	-16.6
900		LEVEL	0	0
200	30	DO	18	18
<hr/> 19,985				

KNOWVILLE - E. GALESBURG

E. GALESBURG -
KNOXVILLE

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
--------	-----------	--------------------	-----------------	------------

725		LEVEL	0	0
-----	--	-------	---	---

200	30	DO	18	18
-----	----	----	----	----

1,600		DO	0	0
-------	--	----	---	---

175	3	DO	1.8	1.8
-----	---	----	-----	-----

25	3	0.57	13.2	-9.6
----	---	------	------	------

675		0.57	11.4	-11.4
-----	--	------	------	-------

200		LEVEL	0	0
-----	--	-------	---	---

C. B. and Q. Main Line

100		LEVEL	0	0
-----	--	-------	---	---

400		0.67-13.4		13.4
-----	--	-----------	--	------

550		LEVEL	0	0
-----	--	-------	---	---

350		0.47	9.4	-9.4
-----	--	------	-----	------

400		0.77-15.4		15.4
-----	--	-----------	--	------

660		2	-40	40
-----	--	---	-----	----

1,600		LEVEL	0	0
-------	--	-------	---	---

700		0.7	-14	14
-----	--	-----	-----	----

800		LEVEL	0	0
-----	--	-------	---	---

500		1	20	-20
-----	--	---	----	-----

600		LEVEL	0	0
-----	--	-------	---	---

500		1	-20	20
-----	--	---	-----	----

600		LEVEL	0	0
-----	--	-------	---	---

1,120		1.5	30	-30
-------	--	-----	----	-----

100	3	1.5	31.8	-28.2
-----	---	-----	------	-------

100	3	1.4	29.8	-26.2
13,180			-51-	

E. GALESBURG - GALESBURG LIMITS

GALESBURG LIM -
E. GALESBURG

LENGTH	CURVATURE	% GRADE UP DOWN	CORREC- TION	CORRECTION
120		1.4	28	-28
900		0.33	-6.6	6.6
700		LEVEL	0	0
1,400		0.3	-6	6
100		0.17	-3.4	3.4
200	3	0.17	-1.6	5.2
300		0.17	-3.4	3.4
400		2	-40	40
1,000		LEVEL	0	0
800		1.5	30	-30
400		LEVEL	0	0
1,140		0.8	-16	16

C. B. and Q. SPUR

1,120		LEVEL	0	0
1,300		0.6	12	-12
<u>1,500</u>		0.2	-4	4

11,380

(B). EQUIPMENT

The car equipment will essentially consist of the following apparatus:

(1) 4, G. E. 66-A-9 commutating pole motors of 125 hp. each with a gear ratio of pinion 29 to gear 60 (≈ 2.07) Since the service involves the use of both 600 and 1200 volts, the motors are to be wound for 1200 volts. The motor circuits will remain the same, which will result in operation at half speed on a 600-volt trolley. The motors will be operated in series on 1200 volts and in multiple on 600 volts.

(2) Since single cars are to be operated, the Sprague - General Electric Type MK (hand operated) control will be used.

(3) In order that the control and auxiliary circuits may be operated at 600 volts, whether the car is running on 600 or 1200 volts, a dynamotor will be a part of the equipment. A switch also will be supplied to connect the control circuits to the trolley on 600 volts, and to the dynamotor on 1200 volts, so that the control circuits will always be operated from the same potential.

Heaters are to be fed directly from the 1200-volt trolley since they will be wound and insulated to suit this voltage.

The car can be lighted from the 1200-volt trolley by using special lamps and sockets to eliminate fire hazard; it will be best, however, to supply the lamps from the low side of the dynamotor.

The speed-time curves showing the individual runs between the limits of Peoria and Galesburg will be found on Sheet #12 and #13; those for the return run, i. e., between the limits of Galesburg and Peoria are shown on Sheets #14 and #15.

The distance between the limits of the termini finally determined is 44.32 miles,-- which constitutes the interurban portion of the line. The final speed-time curves show that a mean time of 1 hour, 29 minutes or, say, $1\frac{1}{2}$ hours is required to traverse this distance. Allowing 20 minutes for the additional 5.06 miles in the terminals, a total time of 1 hour, 50 minutes will be required for the run,-- which results in a schedule speed of 31.1 miles per hour.

This total time of run is 17 minutes in excess of the best running time of the C. B. & Q. However, considering the fact that the terminal of the project in Galesburg is within the central (business) part of the city while that of the C. B. & Q. is a considerable distance away from it, and, considering also that the interurban will traverse the busier streets of both terminals thus allowing much convenience to the traveling public, -- it will be fair to say that the schedules will be approximately equalized and a preference for the electric railway very likely will be shown.

Simultaneously with the speed-time curves the current, voltage and power curves were drawn as shown on Sheets #12, 13, 14, and 15. The latter curves will be discussed later.

2. FINAL DETERMINATIONS REGARDING SCHEDULE AND EQUIPMENT

a. Schedule

Since the project is a double-track line it will not be necessary to study the final schedule shown on Sheet #16 with regard to points of meeting of cars. This schedule does not show

the stops or their duration within the city-limits, as these cannot be definite. The slope of the lines is dependent upon speed, the co-tangent of the angle which they make with the horizontal representing the schedule speed of the car.

It will be noted that in this schedule, in accordance with the preliminary one, the first trains leave both terminals simultaneously at 5:00 A. M.; the run from Galesburg to Peoria is made in 1 hour and 48 minutes, while 1 hour and 50 minutes is the time required for the return run. The final schedule further shows that a total of 26 single runs is made throughout the day. The time-table on Sheet #17 was derived from this schedule.

3. ENERGY CURVES. LOAD DIAGRAM

The current-time curves were plotted in amperes per car. The values for power were plotted in kilowatt-seconds. By the use of a planimeter the areas under the power curves were determined. The energy consumed was found to be

$$E = \frac{\text{Area under curve} \times 5280}{3600 \times 45 \text{ tons} \times \text{length of line}} \quad \begin{matrix} \text{watt-hours/ton} \\ \text{mile} \end{matrix}$$

For the run from Galesburg to Peoria, the energy consumption is 61 watt-hours per ton mile, which during the return run 63 watt-hours per

ton mile are consumed.

The energy consumption of one car from each terminal for a single day is next plotted with time in minutes as abscissae and kilowatts as ordinates. The kilowatt values are taken from the power curves plotted in connection with the speed-time curves. The curve resulting from summing up these values is the load curve for the station.

Allowing for the possibility of four cars starting simultaneously, also allowing for the power required for lighting and heating, it is found that 1400 K W. is the maximum demand on the station. A quantity as small as this would hardly justify the construction of a power station, since it could be purchased at a favorable rate from Peoria. No power house therefore, will be built. The transmission line is to be erected by the power company. The electrical considerations and the specifications will be found in Section 5.

4. REASONS FOR THE SELECTION OF 1200-VOLT DISTRIBUTION

At present there are in operation three general systems: the 600-volt direct current, the three phase alternating current with induction motors and the single phase alternating current with commutating motors. Recently, a potential of 1200 volts direct current has become a recognized standard on interurban lines because it is conveniently interchangeable in operation at the same speed on 600 and on 1200-volt lines.

The polyspase system was left out of consideration because of the inability of polyphase motors to be operated on direct current. The trolley potential both in Peoria and Galesburg being 600 volts direct current, the choice lies between single phase alternating current and 600 or 1200 volts direct current.

The economical limit for direct current distribution at ordinary voltages of 450 to 600 at the motors, is from 3 to 10 miles as a maximum on each side of the station. The 1200 volt D. C. system reduces the fixed charges

by reducing the number of substations necessary and by a saving in copper in the distribution system, since at a high voltage a smaller current will flow in the wire. An increase in efficiency of the high voltage substation is secured by an improvement of the load factor. Substation units are required to be capable of starting at least two cars simultaneously without exceeding the overload guarantees; as the running current of a train is only about one third of the starting current and since there are considerable periods when coasting and braking that the car is taking no current and periods when there are no cars on a section fed by a particular substation, -- a low load factor will result. With the adoption of the high voltage system, however, the length of the line fed by a substation is greatly increased and consequently the individual substation is working for a greater percentage of the total time; therefore the substation load factor and efficiency are improved.

Single-phase motors at present are inferior to the direct current motor in efficiency and rapid accelerating qualities for a given rating. They are also considerably heavier for a given output thus increasing the weight of car to be accelerated for a given traffic return. Another disadvantage of the single-phase system is its low uncontrollable power factor. The direct current system has no apparatus on the car or between the car and the converters to lower the power factor; in fact, the converters permit the power factor of the transmission line to be raised. A lower power factor means proportionately higher current for a given capacity with increased initial cost of equipment and increased losses.

Alternating current trolley circuits affect adjacent circuits of all kinds on account of static and inductive disturbances. The cost estimate would have to include \$300 to \$500 per mile of route for telephone and telegraph protective devices. On the other hand, conductive influence of direct current due to differences in potential in the return circuit does not create any disturbance in the telephone, and protection for the

telegraph is easily provided.

The fact that 1200 volts and in some cases higher direct current potentials are used on more than 1900 miles of electric railroads in this country, furnishes in itself convincing evidence of the success of this proposed system with respect to initial cost, reliability and low cost of maintenance. It is interesting to note that of a total of 28 roads now using high voltage direct current apparatus, seventeen were completely new roads, 6 were operated by steam, 3 were previously operated by single-phase alternating current and 3 by 600 volts direct current. In every one of the 5 roads that previously were operated at either 600-v. direct current or single-phase, the change to the higher system was made without interruption of the regular services, which speaks highly for the flexibility of the system.

5. TRANSMISSION LINE

1 GENERAL

Standard construction with center poles will be used. These poles will be 40 ft. long (with a 130 ft span), to enable the placing of cross-arms for trolley construction.

The three-phase system of alternating current transmission has been standardized almost exclusively for railway work. This is due to the fact that poly-phase apparatus is necessary for substation units in large sizes and that three-phase system requires but three-fourths the copper of the single-phase installation. Other polyphase systems, although more economical in copper, are complicated because of the greater number of wires. The three-phase system, therefore, will be employed in the present case. The frequency will be 25 cycles per sec.

To get an approximate value of the pressure which will be consistent with economy, the formula given by Mr. A. Still was employed. The pressure in kilovolts is equal to

$$5.5 \sqrt{\text{distance of transmission (m)} + \frac{\text{hp. transmitted}}{200}}$$

In the case of the project the horse-power transmitted is $\frac{1400 \text{ KW}}{746} = 1877$ the distance is 31.52 m. Therefore the pressure

$$E = 5.5 \sqrt{31.52 + \frac{1877}{200}} = 35.2 \text{ K. V.} = 35,200 \text{ volts.}$$

The closest standard voltage is 33,000,-- which will be adopted for the present case.

2 MECHANICAL STRENGTH, ETC.

Only one circuit will be installed; therefore, to be better able to withstand abnormal stresses it will be made mechanically stronger than would be the case if two parallel circuits were employed, when one would act as a relay for the other if a break-down should occur.

After carefully considering the advantages and disadvantages of both copper and aluminum wire, the former was decided upon.

Kelvin's law was not used in determining the size of the wire because it would result in a wire too small to withstand the mechanical stresses and weather conditions. The size of wire from the station at Peoria, where power will be purchased, to the Eden substation will be No. 4/0 B. & S., and for the section between the substations at Eden and Maquon the size of the conductor will be No. 0 B. & S.

(b) SPANS

1 The standard length of span will be 130 ft. At Spoon River, due to the long span, poles specially tested for greater strength will be used.

2. The clearance between rail and conductor will in no case be less than 20 ft.

3. When crossing over telephone wires, the clearance will not be less than 10 ft.

4. The distance between wires will be 36 inches, except at Spoon River it will be 45 inches on account of the long span.

5. The poles will be set in the ground to a depth of 6 ft.

(c) METHOD OF ARRANGING WIRES

The "wish-bone" arm arrangement will be employed. As seen from Sheet #19, the wires are placed at the vertices of an equilateral triangle, with two conductors in one vertical and the third wire at the third vertex. To provide greater protection against lightning, a ground wire will be strung along the top of the poles, --these being 8 inches in diameter at the top.

(d) INSULATORS

The pin type insulator will be used. The length of the pin will be such that the distance between the smallest petticoat and the cross-arm is 4 inches, which is one inch greater than the flash-over distance from the edge of the inner petticoat to the pin.

3. ELECTRICAL CONSIDERATIONS

(a) EDEN - MAQUON

Length, miles	20.78
Power from Eden substation, kw.	700
Power factor, full-load current leading	90%
Frequency, cycles per second	25
Voltage in line at Maquon	33,000
Voltage from line to neutral ($\frac{33000}{\sqrt{3}}$)	19,100
Assumed loss	5%
Actual loss	1.5%
Size of wire, No 0 E.A.S., inches	0.325
Resistance per mile, ohms	0.529
Distance between wires, inches	36
Inductance per mile, henries	0.001853
Capacity per mile, micro-farads	0.0163

The remaining calculations were performed by the use of hyperbolic functions which give much greater accuracy than the method of "drops".

Attenuation Coefficient	-----= 0.00063 + j 0.00107
Current per wire at Maquon	-----= 13.6 \angle 25°50'
Natural Impedance ohms	-----= 485 \angle -30°35'
Natural Admittance	-----= 1/485 \angle 30°35'
Voltage at Eden	-----= 19,200
Current at Eden	-----= 14.06
Regulation	-----= 0.524 %
Line Efficiency	-----= 95.9%
Charging Current	-----= 0.99 amp.

(b) PEORIA - EDEN

Length, miles -----10.74
Power from station at Peoria to Eden, kw. 1400
Voltage at Eden -----19,200
Size of wire, No. 0000 B. & S., inches 0.46
Resistance per mile, ohms ----- 0.264
Inductance per mile, henries ----- 0.00171
Capacity per mile, micro-farads-----0.0177

Attenuation Coefficient -----0.000386+j0.000945
Natural Impedance -----368 $\angle -22^{\circ}15'$
Natural Admittance ----- $1/368 \angle 22^{\circ}15'$
Generated Voltage ----- 19,500
Generated Current ----- 27.8
Regulation ----- 1.56%
Line Efficiency ----- 99%
Charging Current -----0.583

(c) PEORIA - MARQUON

Regulation ----- 2.095%
Charging Current ----- 1.573
Natural Frequency ----- 1475

The foregoing calculations, resulting in a regulation of 2% for the entire distance, show that the sizes of #0 and # 4/0 of wire for the two sections are more than suitable for this transmission line.

6. SUBSTATIONS

1. LOCATION

There will be two substations of equal capacity; one will be located at Eden, 10.74 miles from Peoria, and the other at Maquon, 31.52 miles from Peoria.

2 EQUIPMENT

To provide for lighting, heating and the possibility of four cars starting simultaneously the substation capacity must be larger than would be indicated by the load curve.. The converters being built for at least a 25% overload, momentary overloads will be easily taken care of.

a CONVERTERS

Two 500-kw 1200-volt 25-cycle rotary converter units will be installed in each substation, - one to act as a relay in case of emergency. Compounded converters will be used to automatically compensate for the drop due to line, transformers

and converter impedance.

5 TRANSFORMERS

Three single-phase 185-kw. 33000-volt air-blast transformers will be installed for each converter. The primary windings will be connected in "Y" with the neutral solidly grounded. The service may then be maintained in case of trouble on one phase of the transmission line, the other two wires and ground serving as the circuit.

c. REACTANCES

To enable the direct current voltage to be altered by the field rheostat or automatically by compounding, which calls for a corresponding change (by compounding, which calls for a corresponding change) of the alternating current voltage, a three-phase reactance coil is provided between the low tension windings of the transformer and the converter. Under heavy load, the series field of a compound converter tends to produce leading currents, which tendency is practically balanced by the reactance, improving the power factor of transformers, lines and generators when loaded.

One 75- k. v. a. 25-cycle 60-volt air-blast reactance will be used for each transformer set.

a. BLOWER

The following amount of air will be supplied by the blower:

Transformers, each requiring 750 cu. ft./min, --2250

Reactance - - - - - 320
2570

For the two units 5140 cu. ft. of air per minute will be required, - in case both units should be in use. A 6000 cu. ft./min (pressure of 7/8 oz. per sq. in.) blower will be used; it is to be driven by a 3-hp. three-phase induction motor.

(e) SWITCHBOARD

The switchboard panels are as follows:

A. C. Main Panels

(1) Incoming main panel

(2) High tension converter panel

D. C. Main Panels.

{3} D. C. Converter Panel

{4} D. C. Feeder Panel.

In addition to the above there will be several auxiliary panels not incorporated in the main switchboard: A. C. starting panel, blower motor panel, and control storage battery panel. The latter will be used for 120-volt storage

batteries which are required for lighting and for the operation of motor-driven oil switches in case the latter should be finally decided upon.

Besides the electrical equipment, other details of the substation may be considered.

(f) CRANE

²⁵⁻
A₁ ton crane will be installed not only for its convenience but also on account of the actual economy of building floor area, which is possible with its use. The possible saving of time when it becomes necessary to work on machinery rapidly, need hardly be mentioned and the value of a crane at such times is obvious.

(g) DRAINAGE

The walls of the air-blast chamber will be water-proofed and the substation built at such an elevation that water will not stand on the floor of the air-blast chamber. This will be done to prevent any possible damage to the transformers by the warm air from the blower picking up moisture and depositing it in transformers which are not in service.

(h) BUILDING

The front and sectional elevations,

the plan and the wiring diagram will be found on Sheets #20,21,22,and 23.

7 DISTRIBUTION SYSTEM

(a) FEEDERS

The size of feeder determined for the section from the Eden substation, was 500,000 c. m. (without taper), giving an R. I drop of 193 volts; for the section from the Maquon substation the size determined was 550,000. c. m. with an R I drop of 209 volts.

(b) TROLLEY

The trolley wire will be No. 000 in size and will be attached to the hanger by clips embracing only the upper half of the wire. The trolley wire will be tapped on the feeder at intervals of 1000 ft.

The feeders and trolley wire will be carried on the same poles as the transmission line. Lightning arresters are to be installed every 1000 ft. and will be tapped alternately to the trolley and the feeder. Double bracket construction is to be used; it is shown on Sheet #19.

8 CONCLUSION

Since the project traverses a territory

considered one of the most favorable in Illinois. since its terminals are two important and rapidly growing cities, and since similar lines will soon be built between Peoria and the cities of Keokuk and Quincy, it is obvious taking into consideration the conclusions of part A, that the success of the project is assured.

BIBLIOGRAPHY

Standard Handbook

Foster: "Elec. Engineers' Pocketbook"

Gotshall: "Elec. Railway Economics"

Harding: "Electric Railway Engineering"

Hobart: "Electric Trains"

Ashe: "Electric Railways."

Sheldon)
and } : "Electric Traction and Transmission."
Hausmann)
Still: "Overhead Electric Power Transmission."

Lundquist: "Transmission line Construction."

Gillette: "Cost Data."

Nichols: "Lecture notes and Cost Data."

Elec. ry. jour. Aug. 23 - 1913

Sept. 6 - 1913

Sept. 20 - 1913

Nov. 15 - 1913

Trans. A. I. E. E. 1902 pg. 901
169

129

210

809

1903 pg. 91

133

657

1904 pg. 691

1905 pg. 1097

1910 pg. 1

1461

1495

General Elec. Rev. Oct. 1913

Nov. 1913

List of Drawings

- Sheet #1: General Location of Project
2: Curve showing growth of population of Peoria.
3: " " " " " of Galesburg.
4: Route in Peoria
5: Route in Galesburg
6: Curve showing relation of intermediate
population to annual operating revenue.
7: Preliminary Schedule
9: Curve of Train Resistance.
10: Characteristics of Motor Selected.
11: Preliminary Speed, current,- voltage,- and
power-time curves.
12: Speed-, Current-, Voltage-, and Power-time
curves between Peoria & Farmington
13: Ditto Farmington & Galesburg
14: Ditto Galesburg and Farmington
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16: Final Schedule.
17: Time-table
18: Load Diagram.
19: Overhead Construction with Center Pole.
20: Front Elevation of Substation.
21: Plan of Substation.
22: Section Elevation of Substation
23: Wiring Diagram of Substation.







SHEET 13

FARMINGTON

WEIGHT

POUNDS

300

200

100

0

2400

2420

2440

2460

2480

2500

2520

2540

2560

2580

2600

2620

LESS INVENTORY

WEIGHT

POUNDS

300

200

100

0

2400

2420

2440

2460

2480

2500

2520

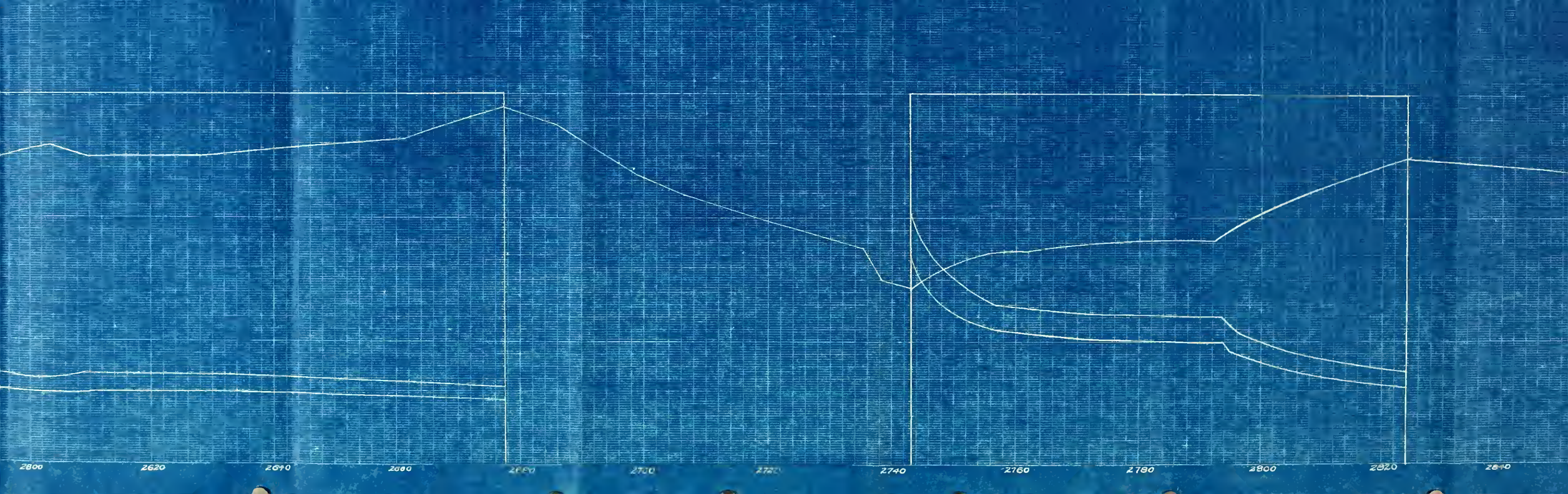
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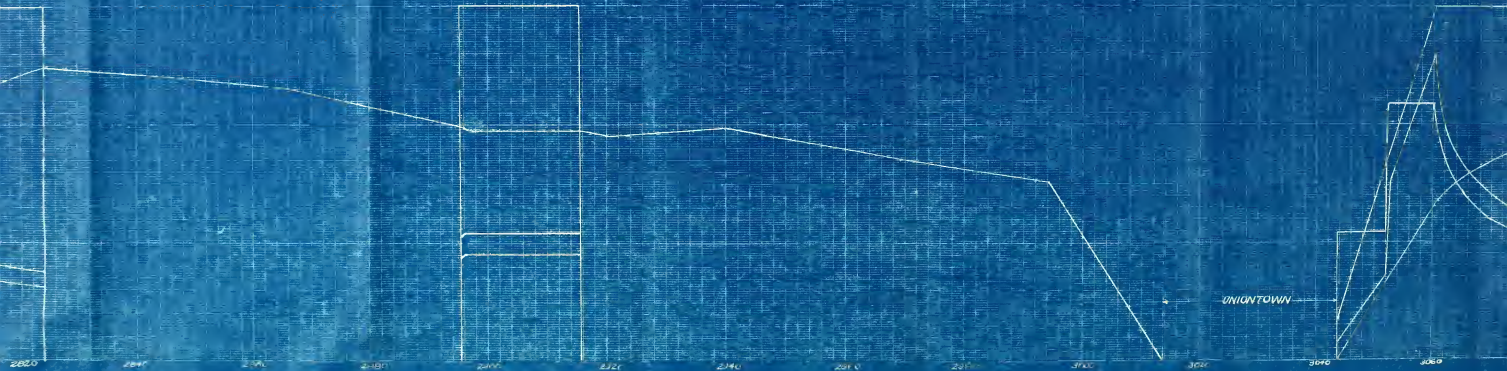
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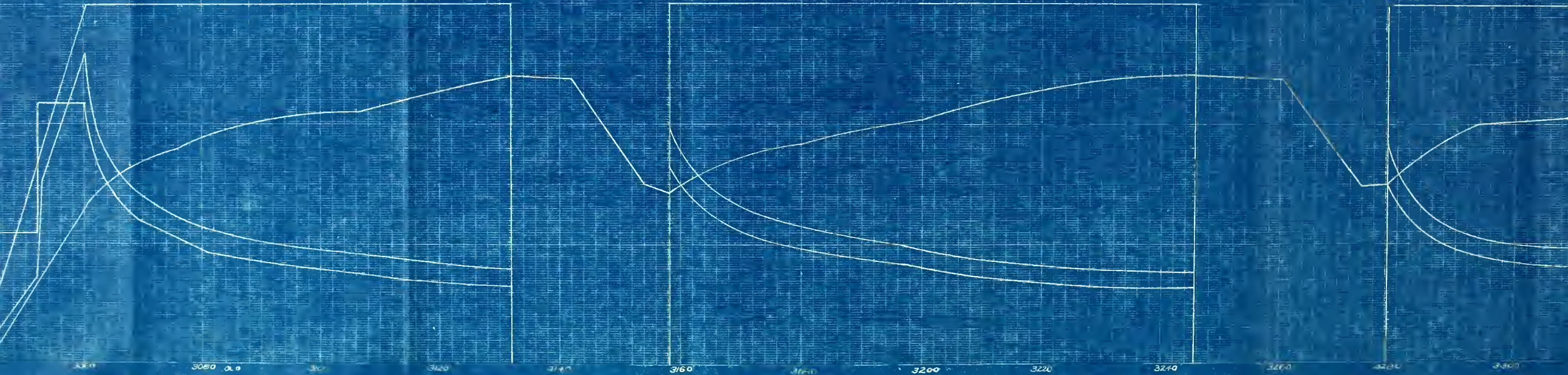
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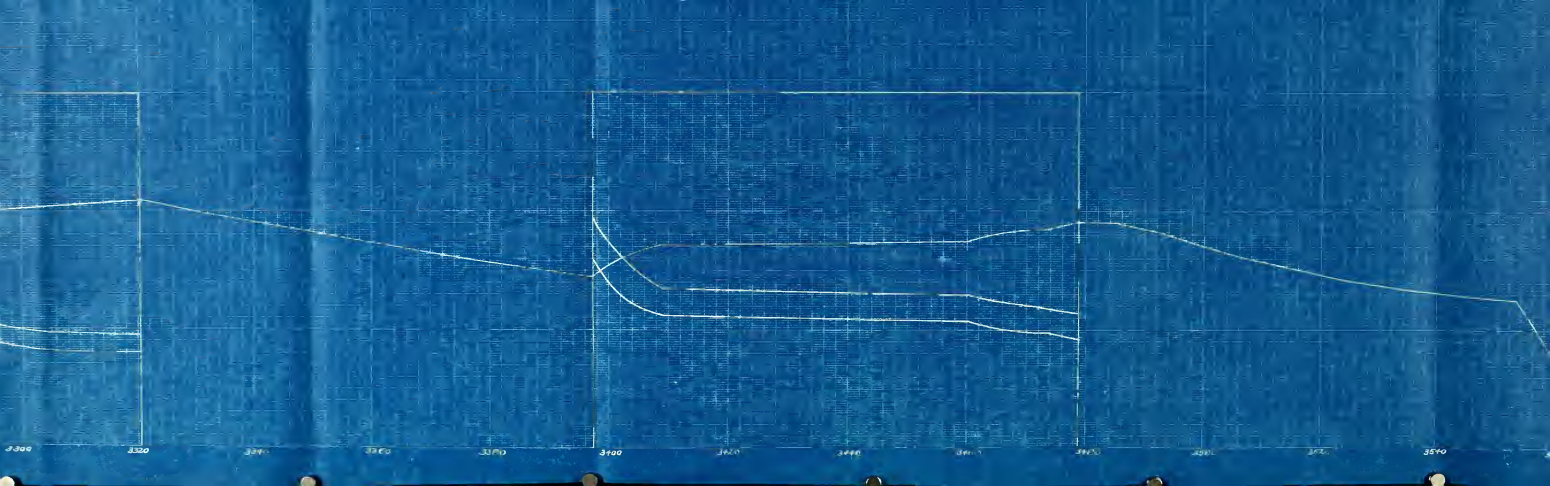
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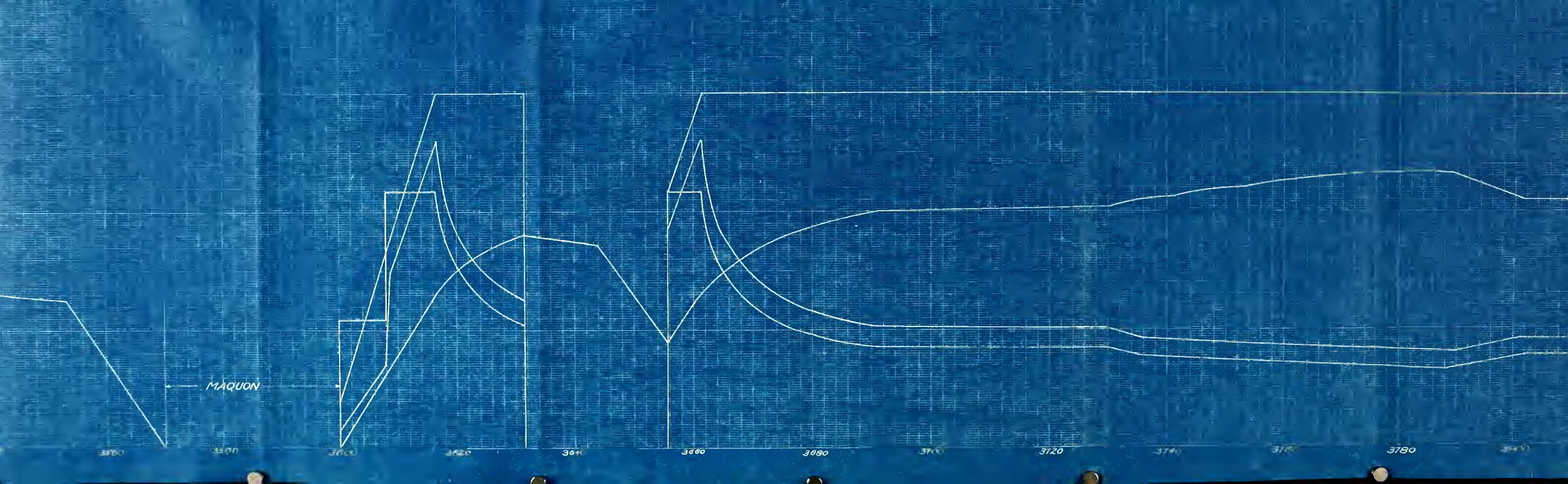
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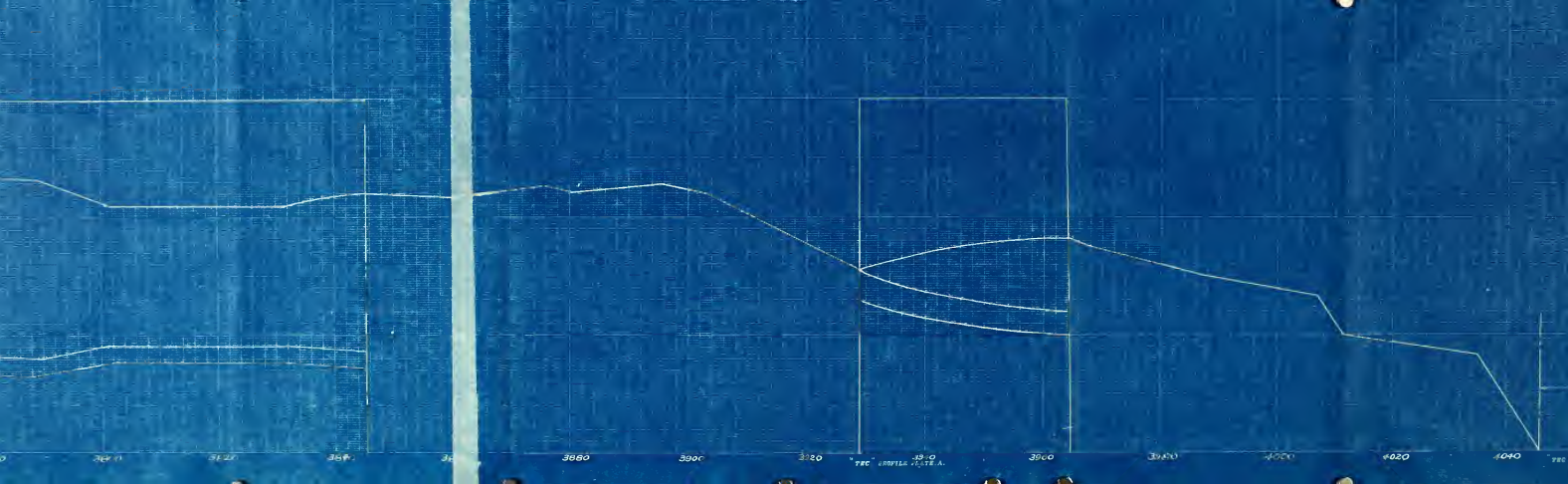


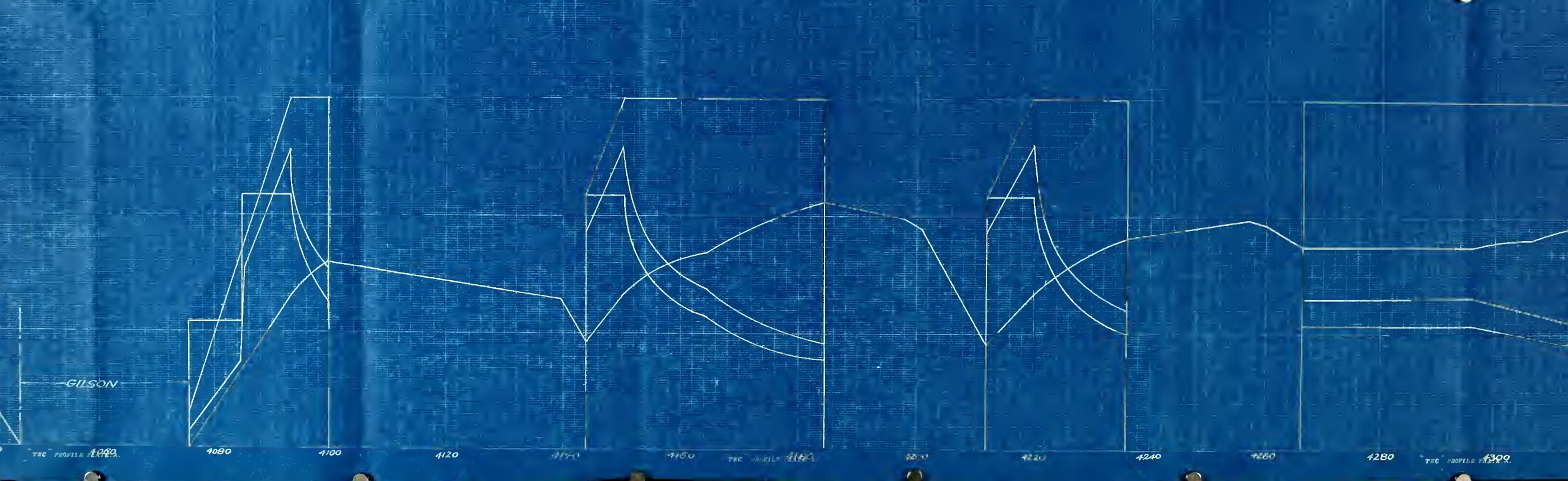


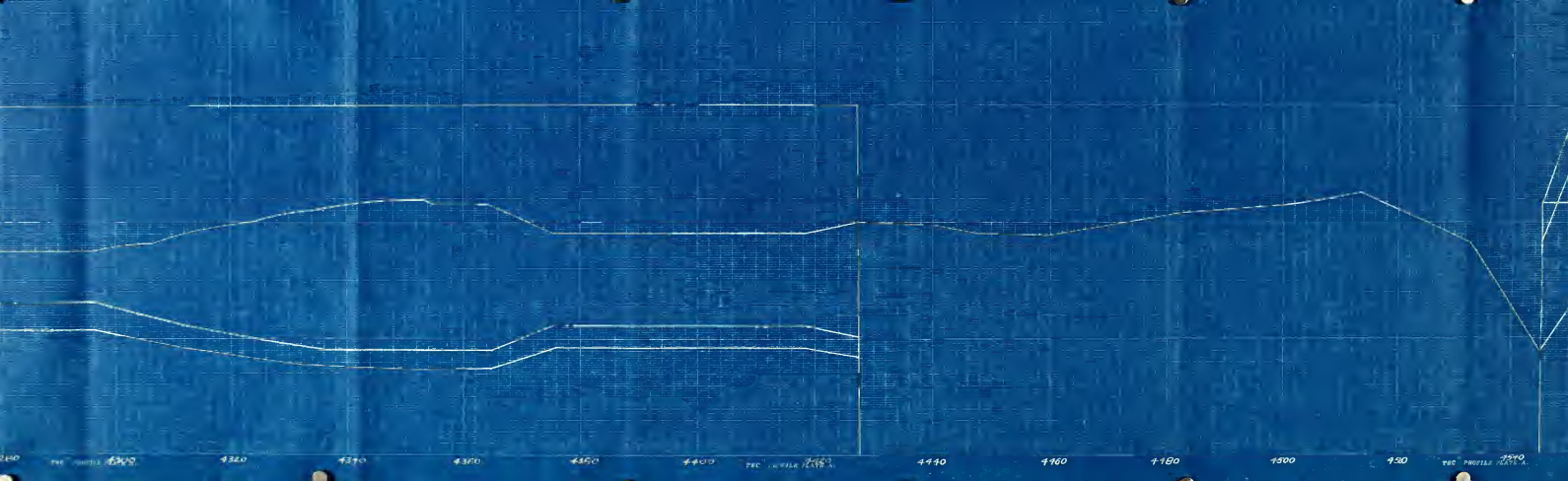


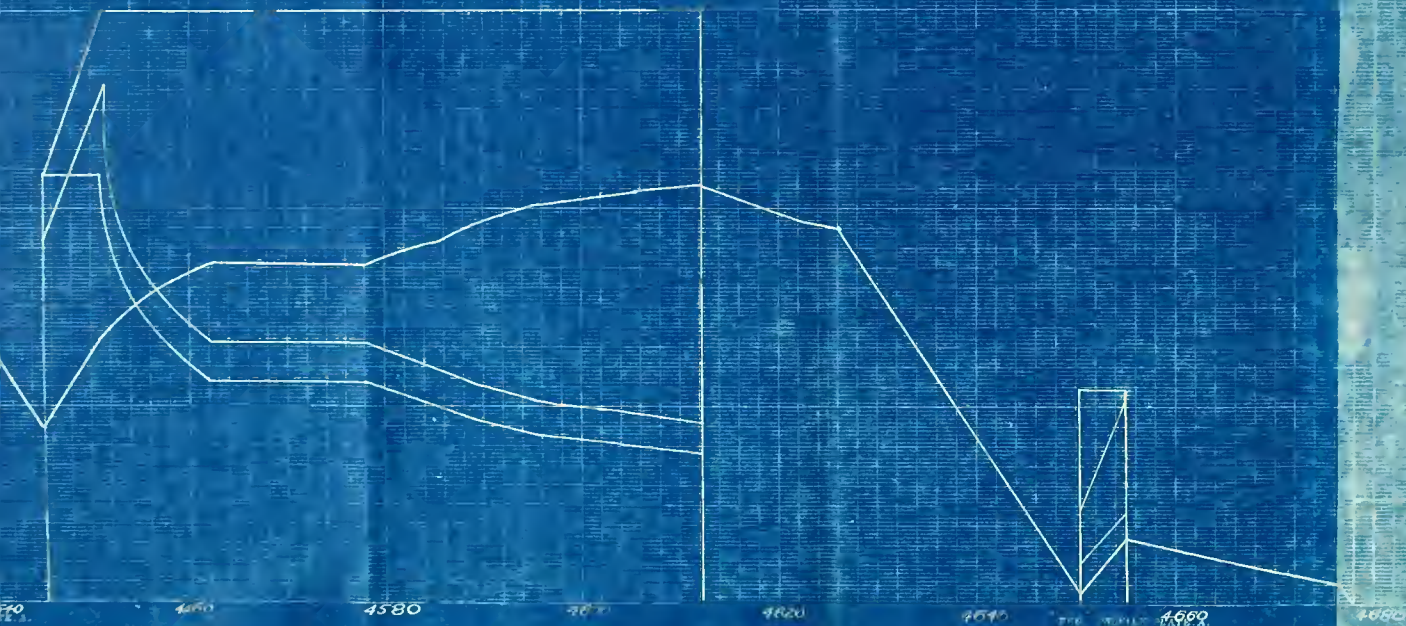




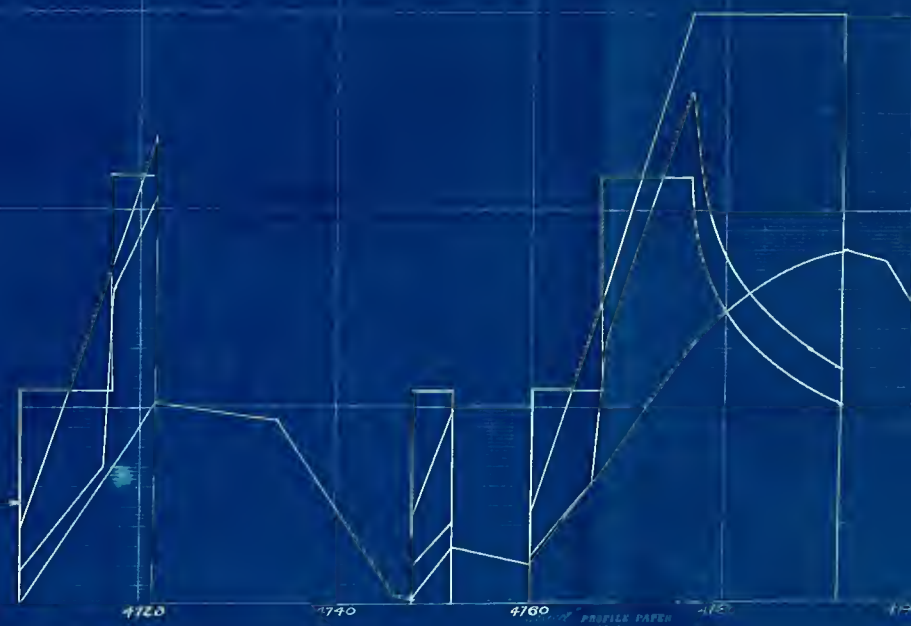


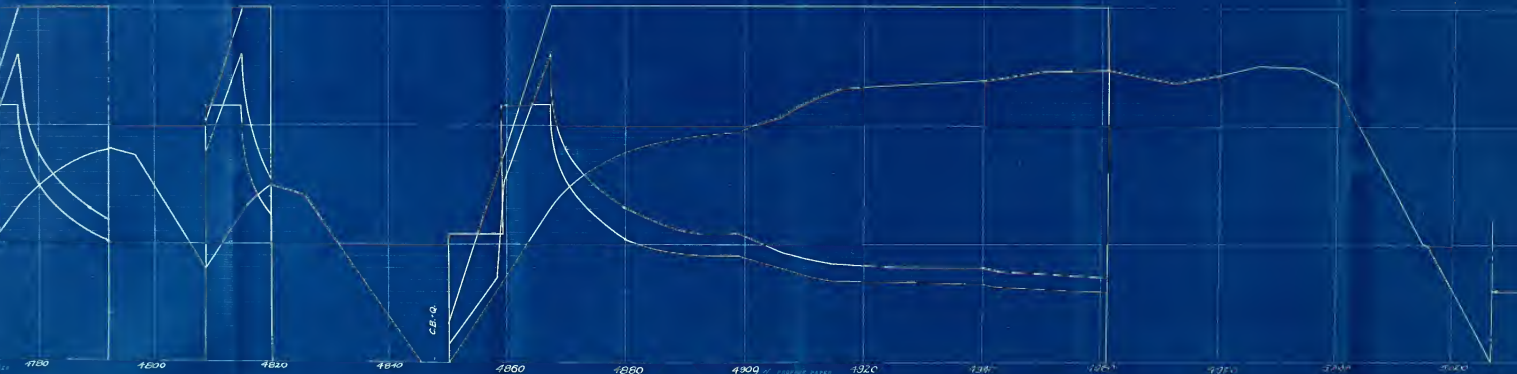


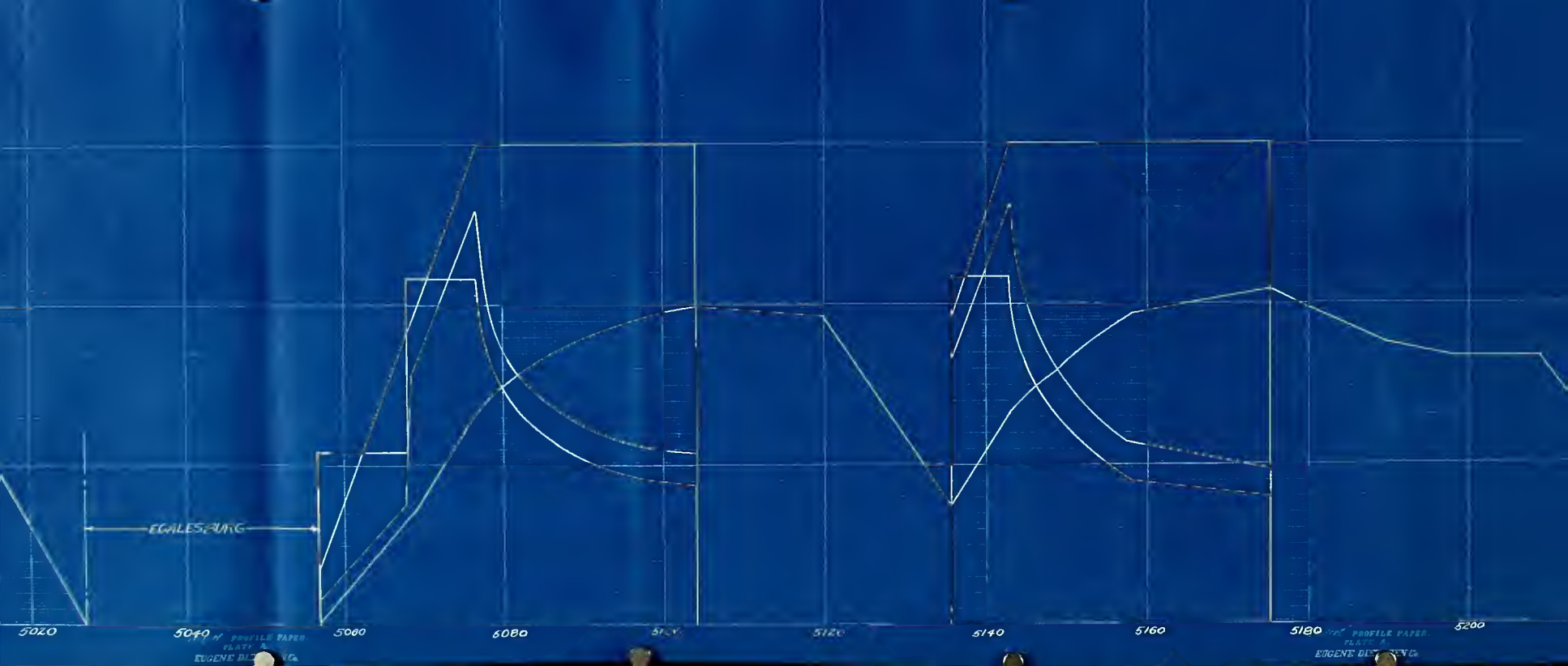


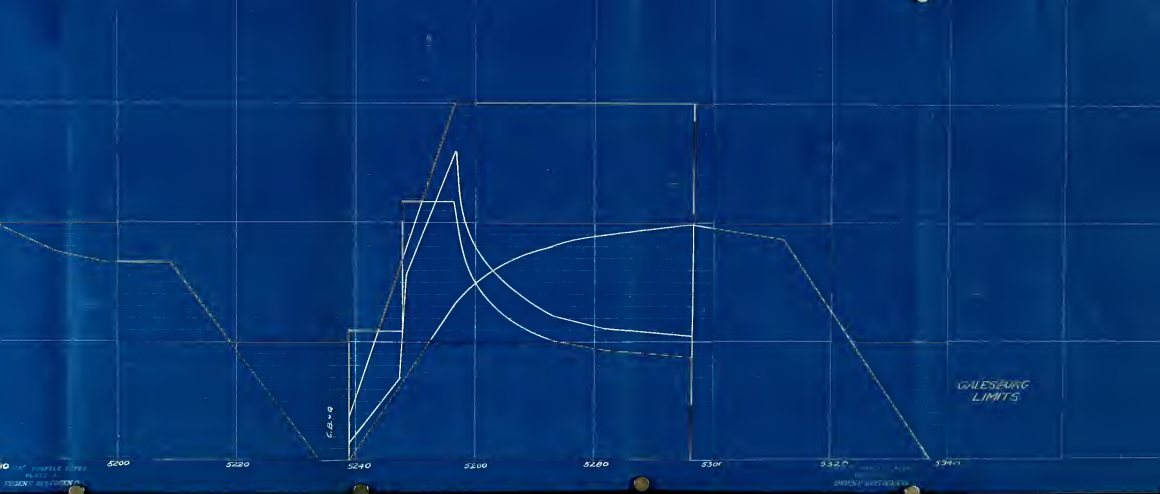


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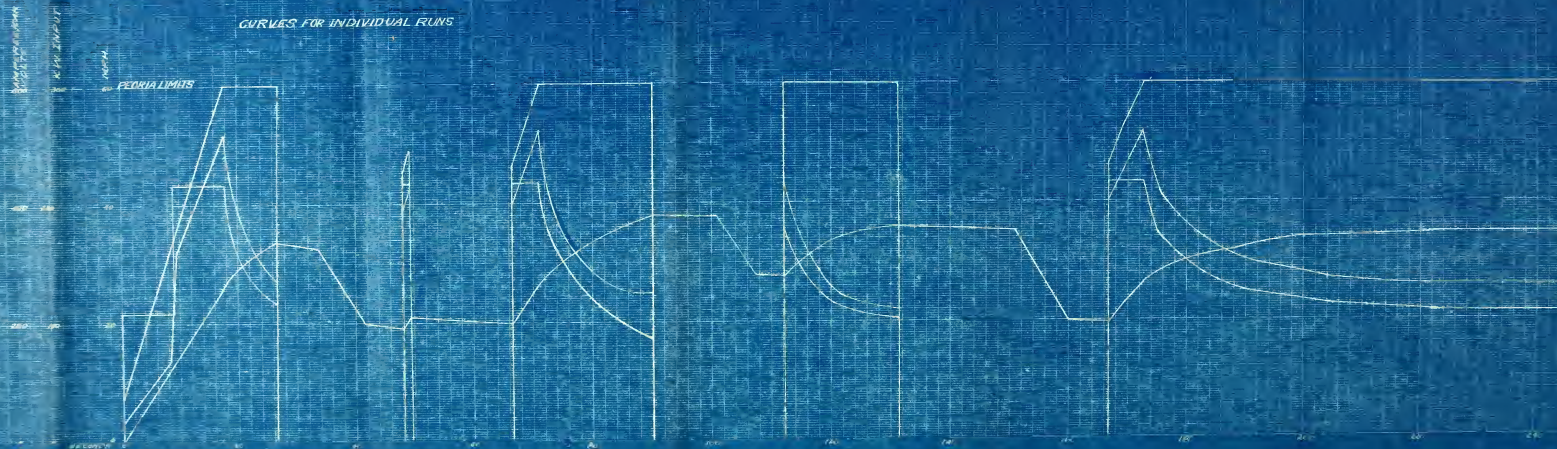


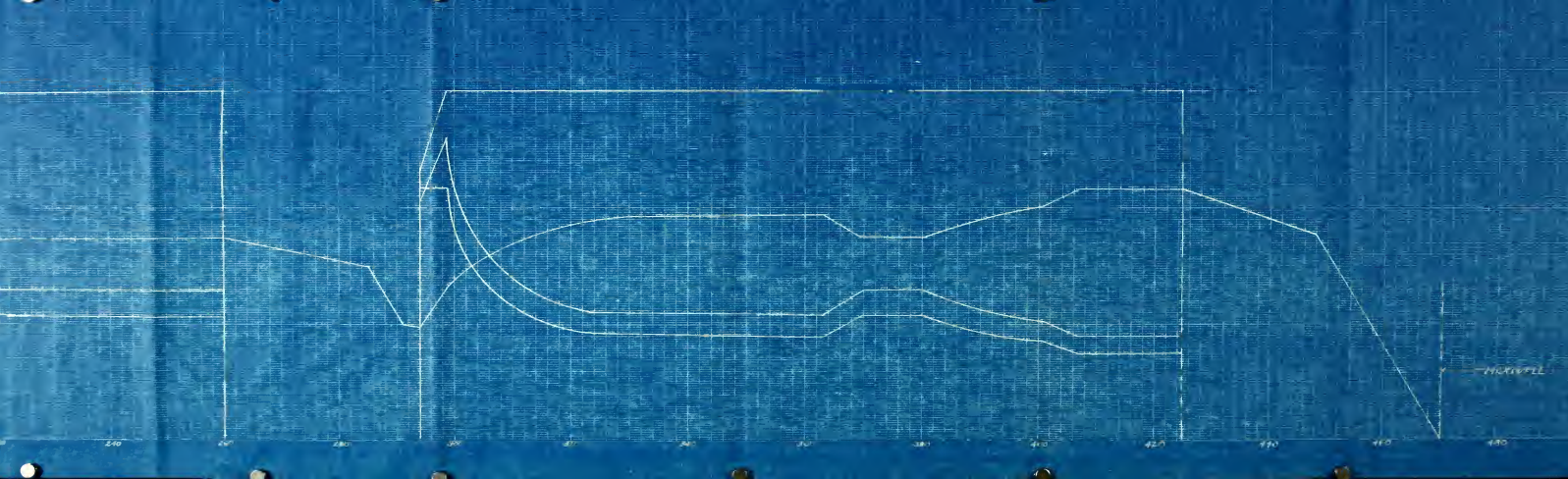


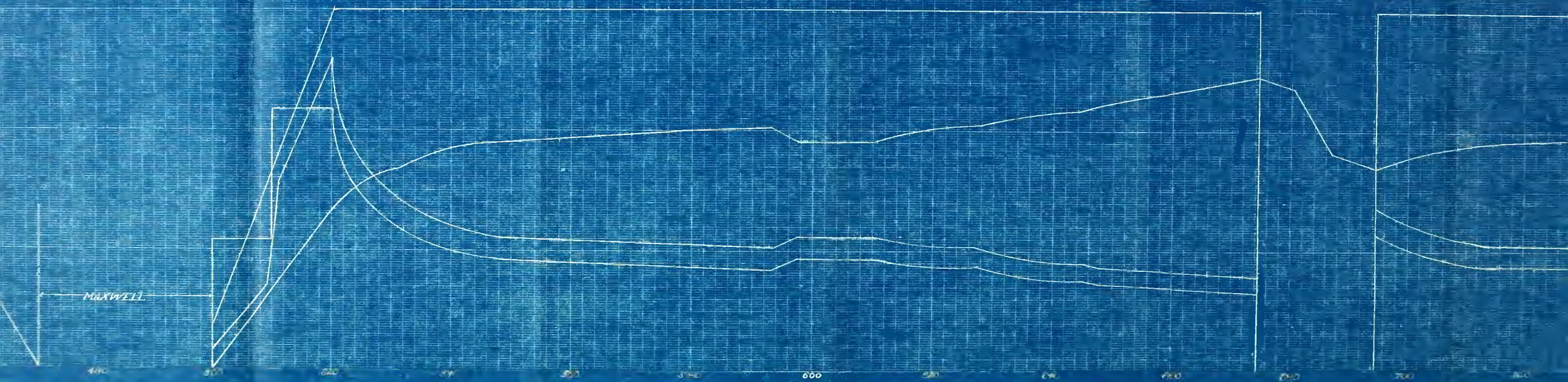


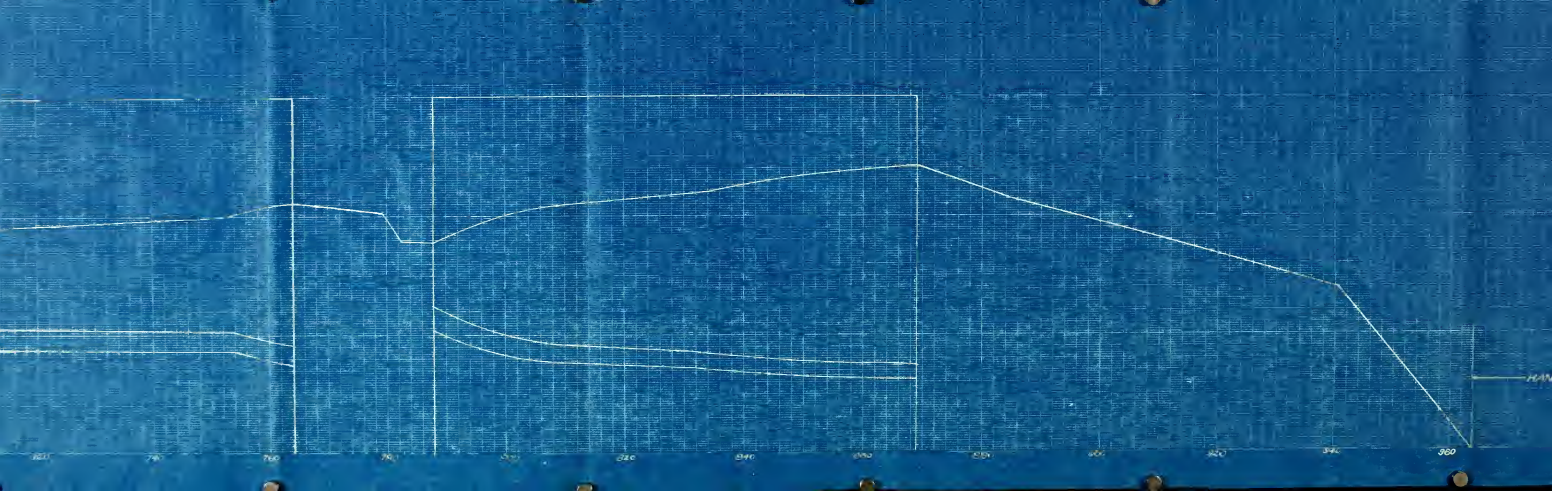


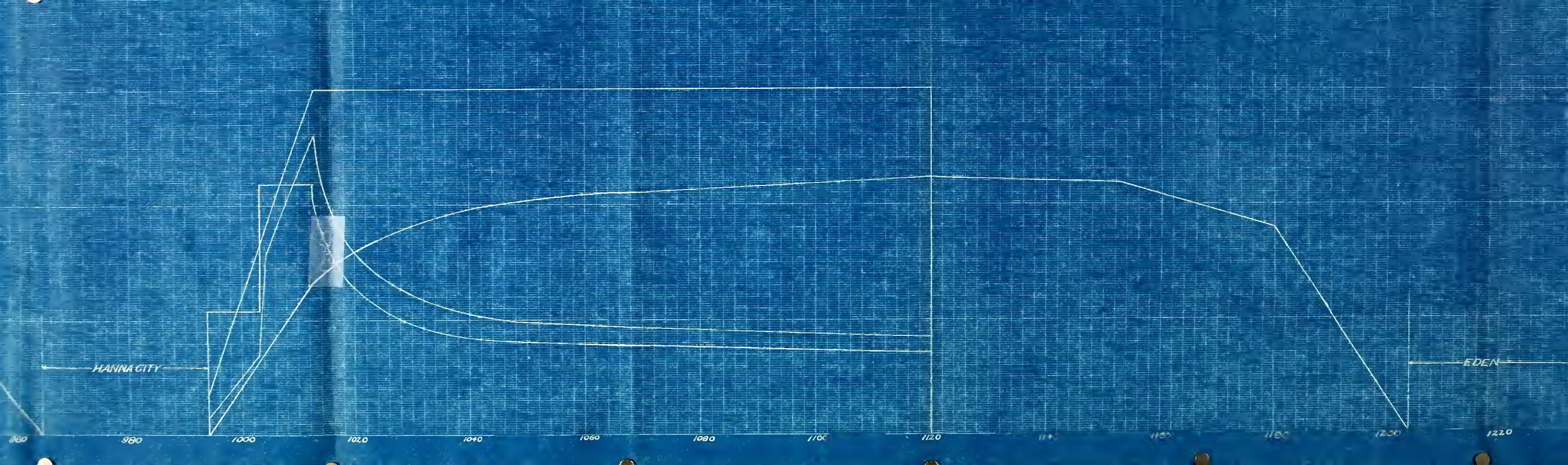
CURVES FOR INDIVIDUAL RUNS

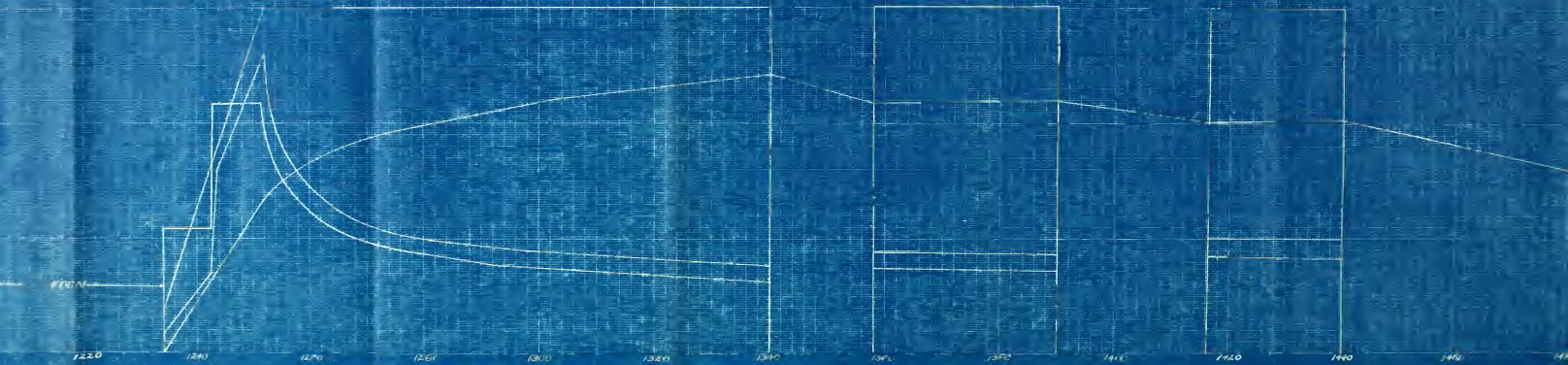


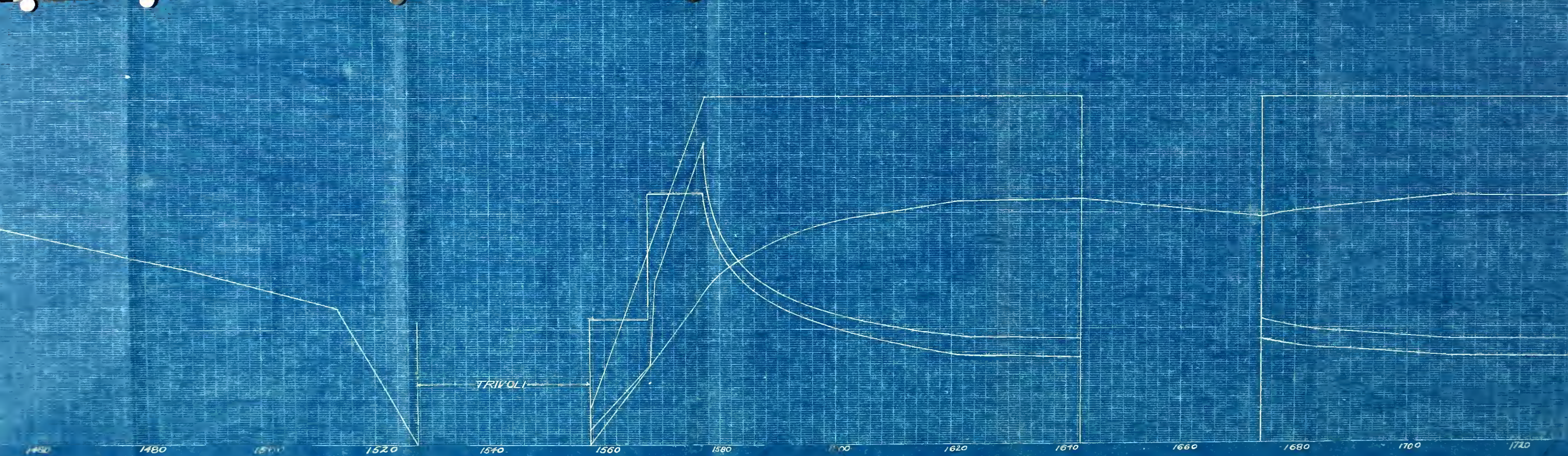


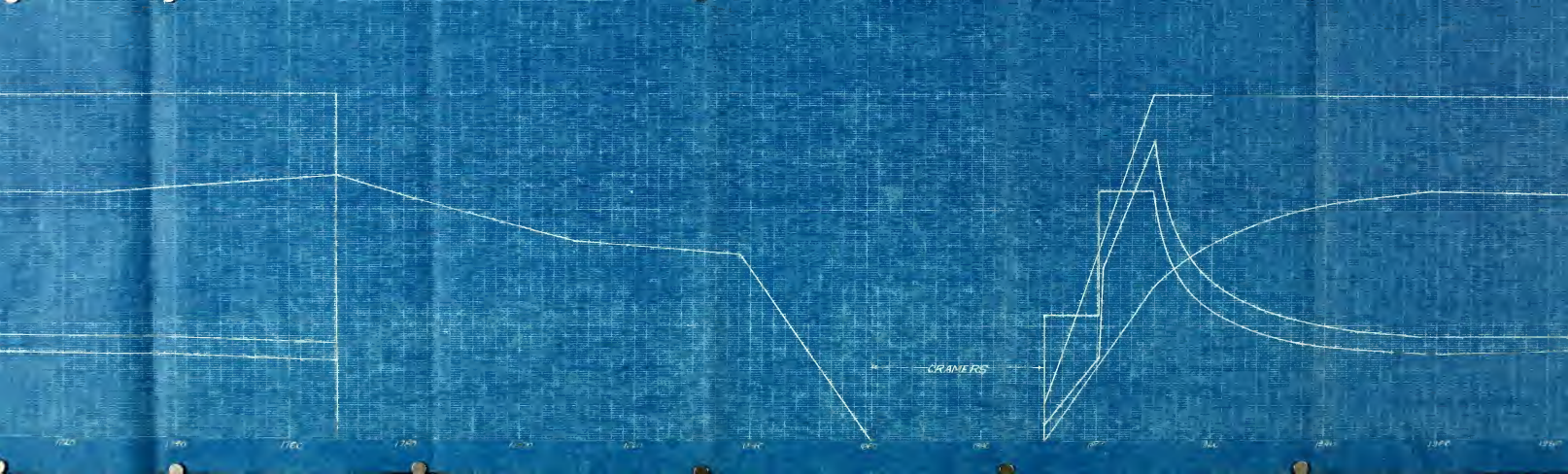


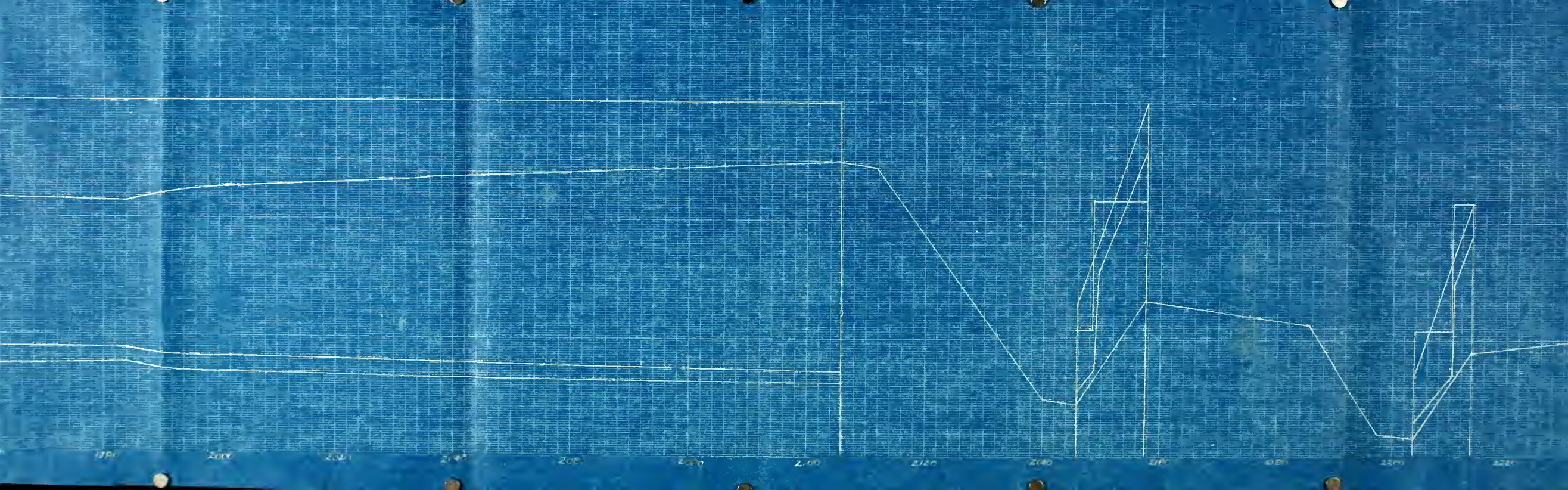


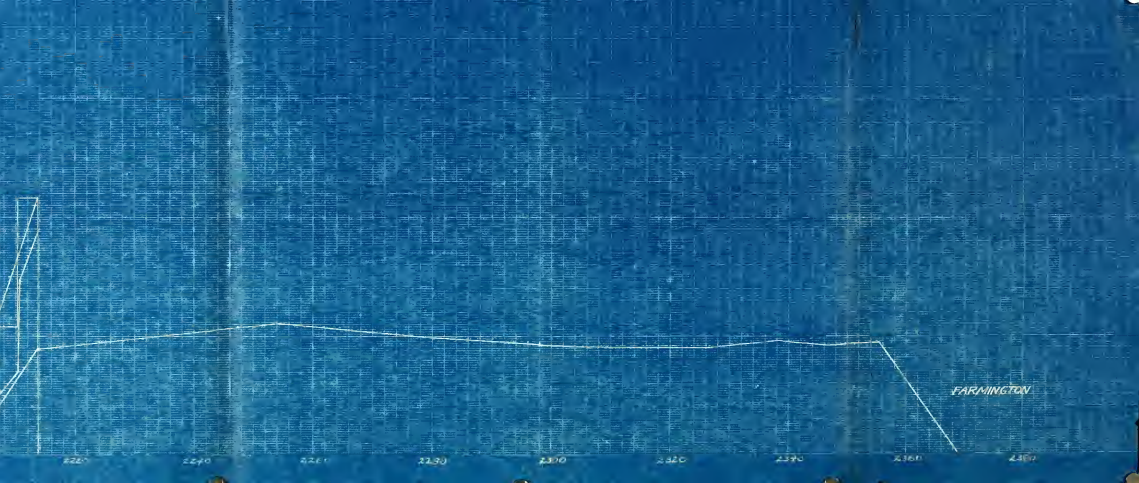












1. W. INPUT
 2. AMPS PER CAR
 3. MILES PER HOUR

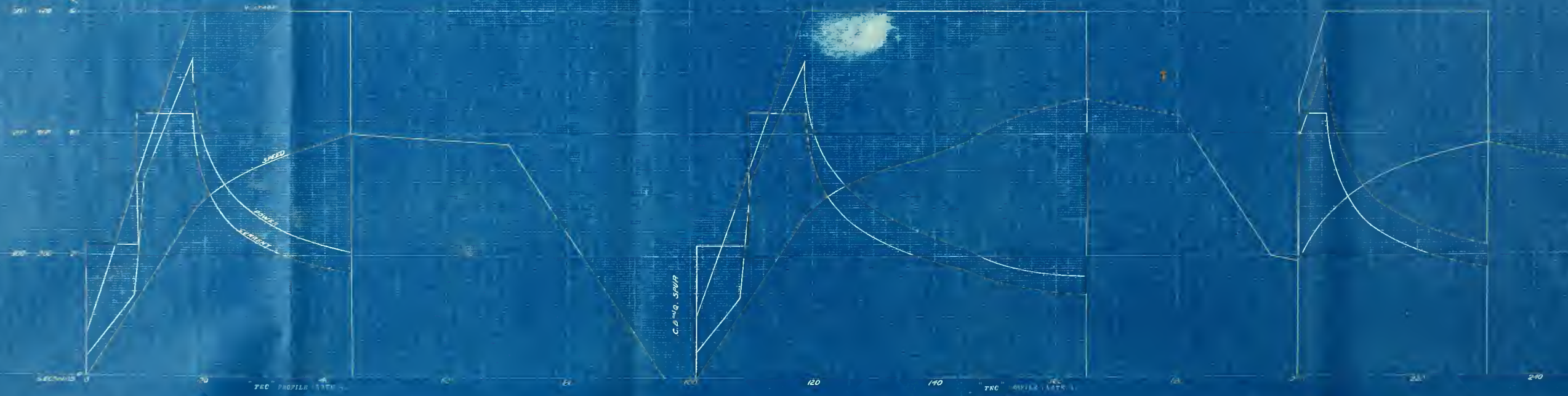
SHEET #14

SPEED, CURRENT, VOLTAGE, and POWER CURVES

P-6 ELECTRIC RAILWAY

34.5
P.L.M.

GALESDURG LIMITS



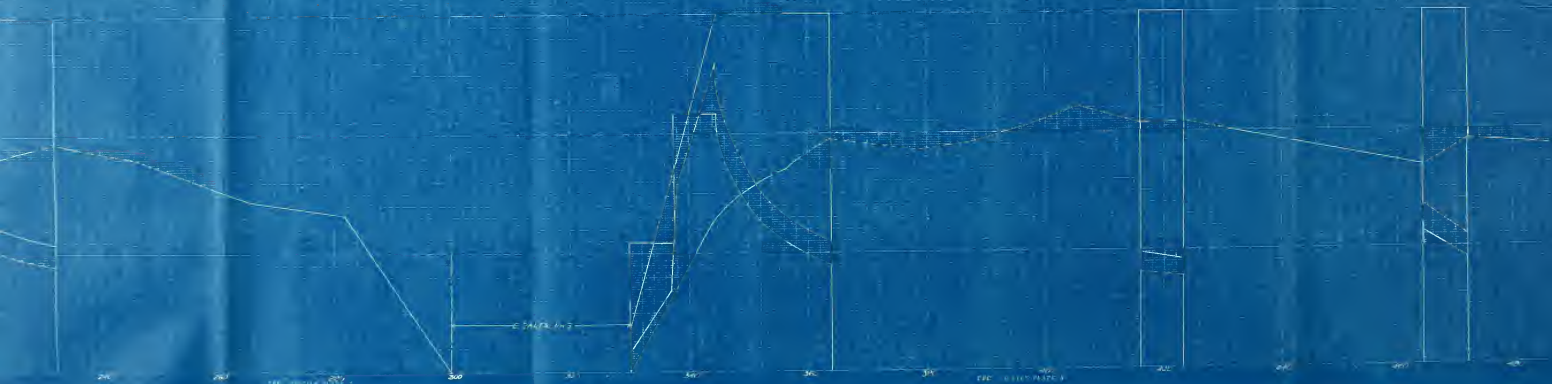
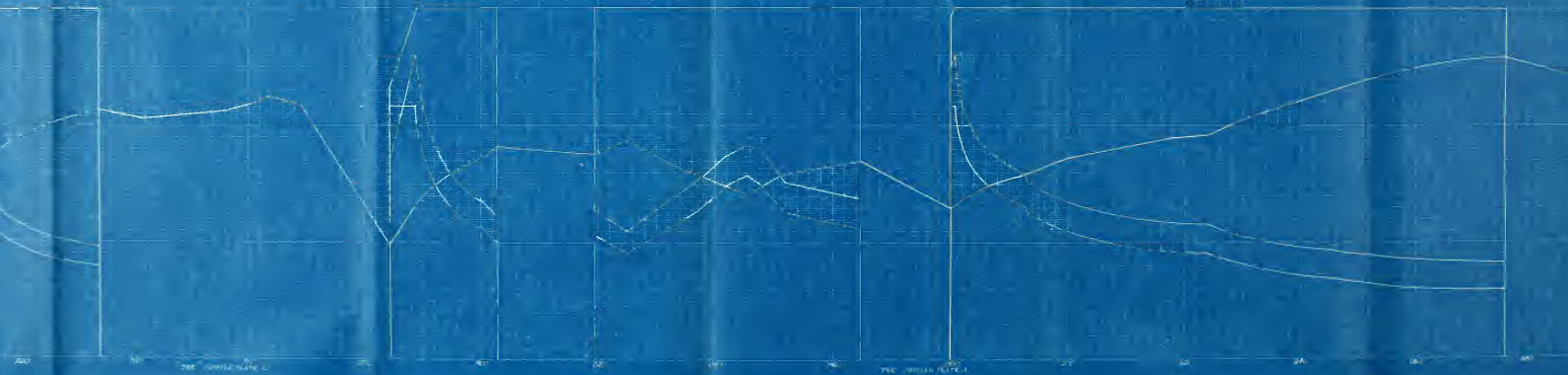
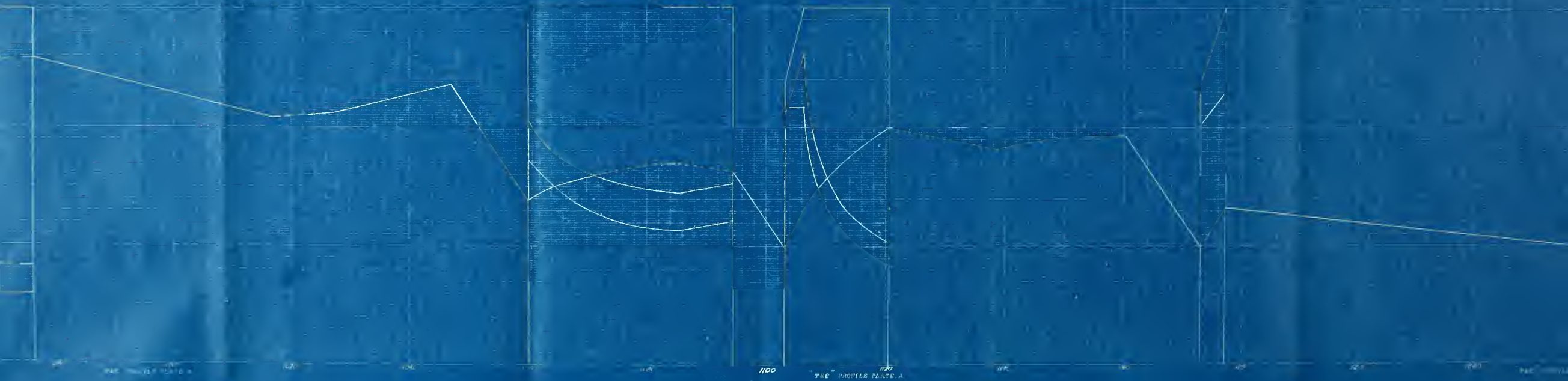
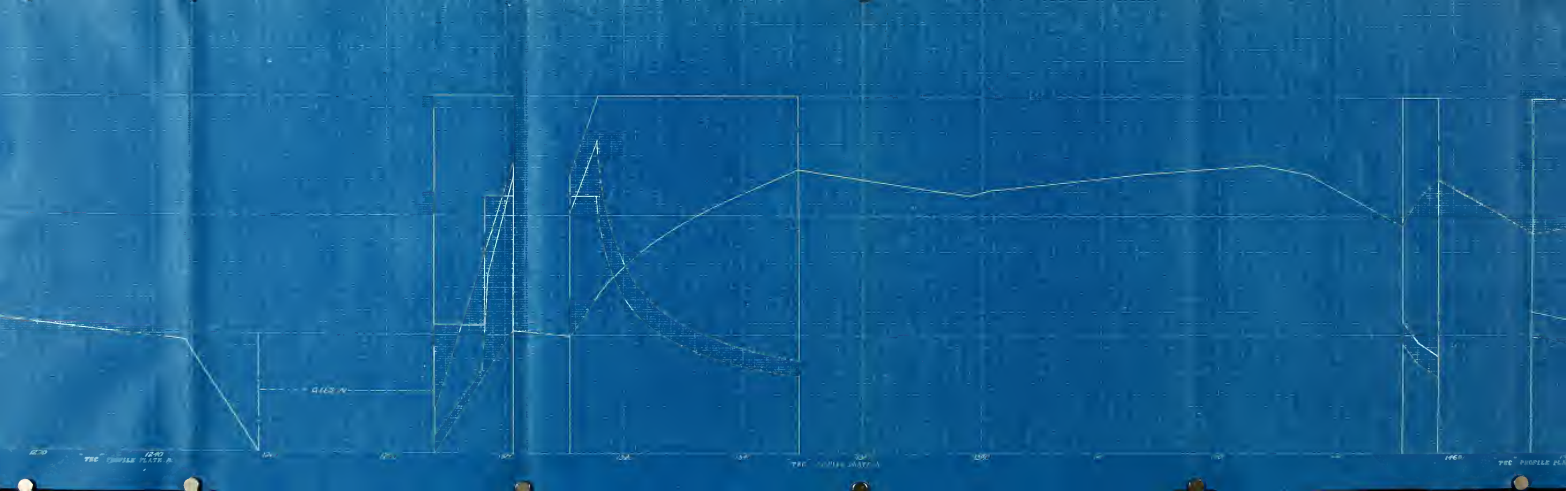


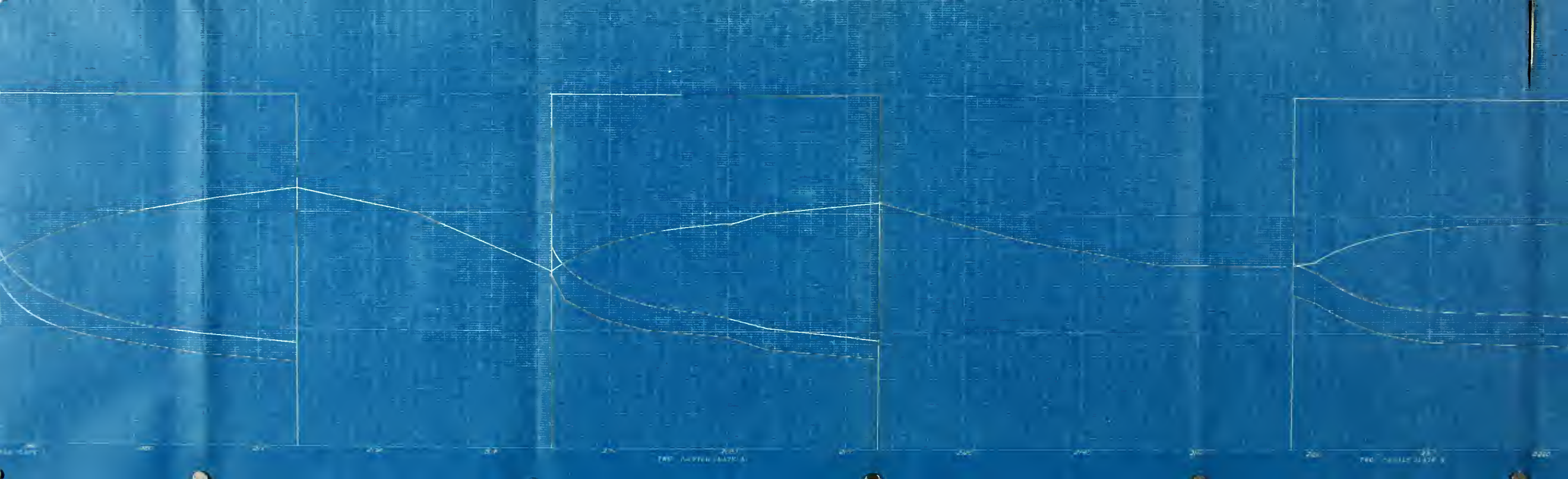
FIG. 1000-1-12

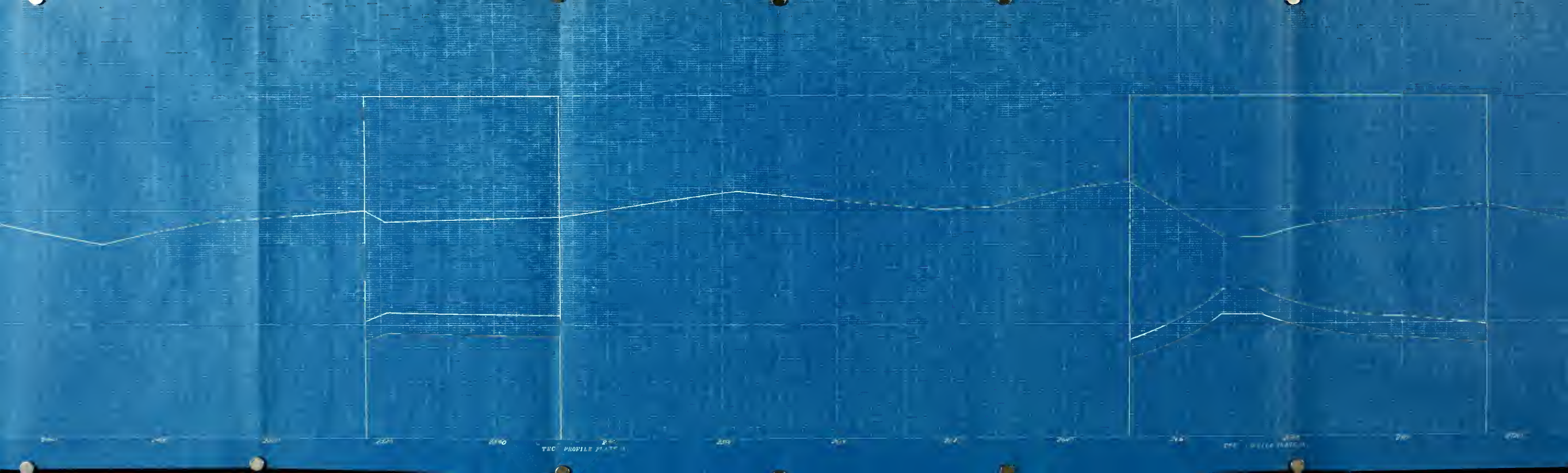
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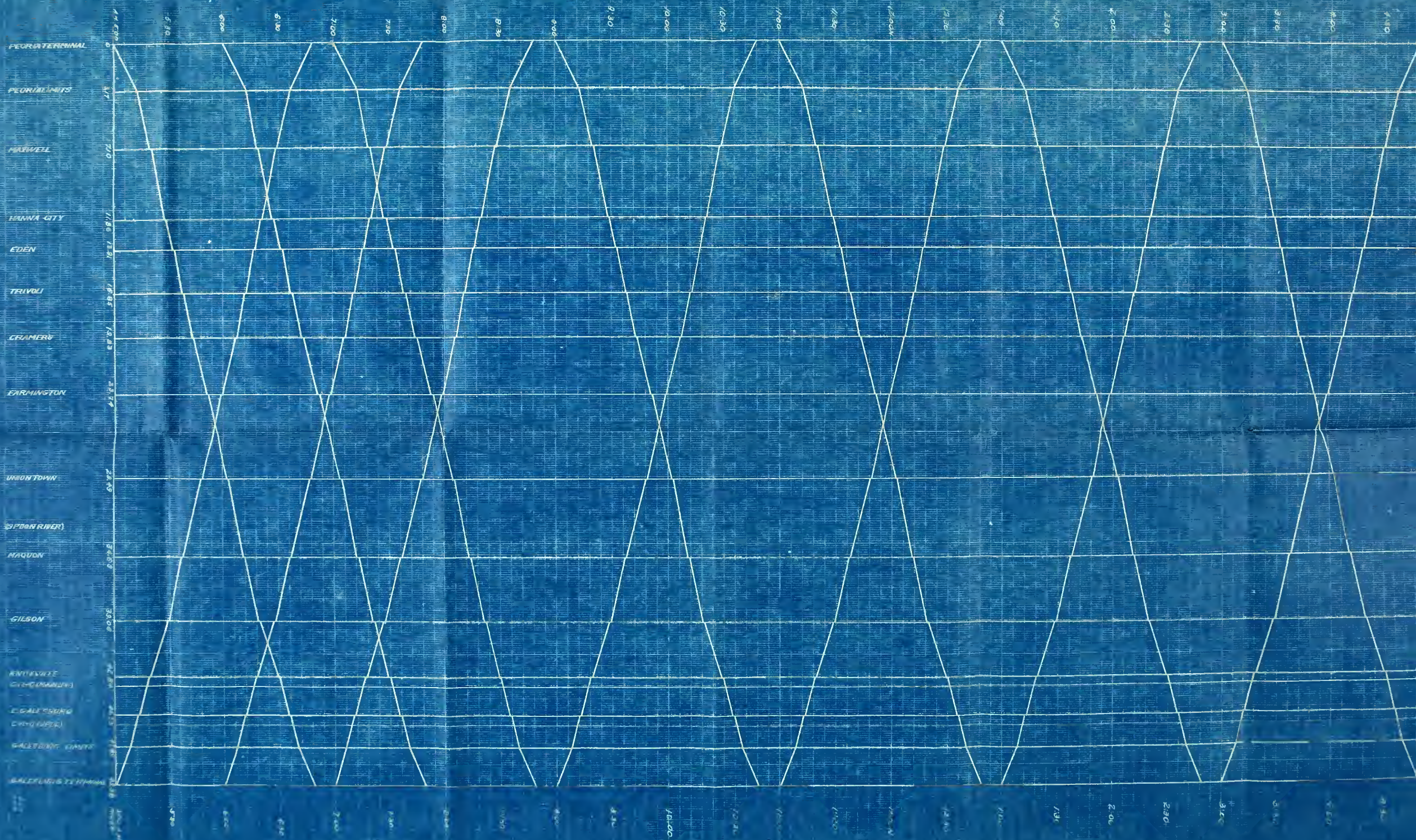




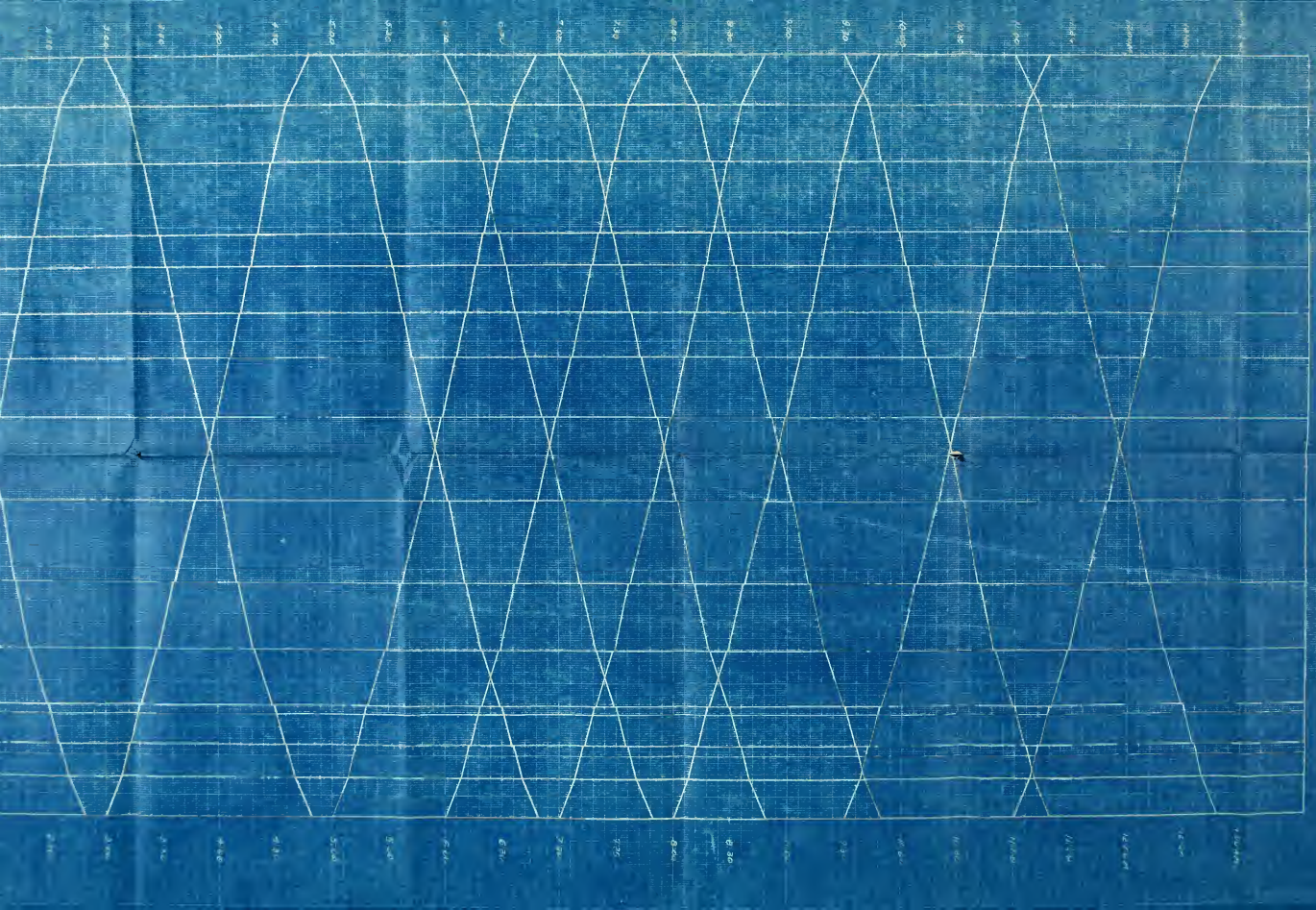








SCHEDULE 4 THE PEQUIN-GALESDUNGELECTRIC CO.





LOCATION OF THE PROJECT

PEORIA-GALESBURG ELECTRIC RAILWAY

3/10/14

J.A.P.
E.L.H.

GILSON (Hwy 36)

HAJON (Hwy 20)

HAJON TWP
GALLEN TWP
UNION TWP (Hwy 1)

KNOX CO

GALLEN TWP

HAJON TWP
GALLEN TWP
UNION TWP (Hwy 1)

HAJON TWP
GALLEN TWP
UNION TWP (Hwy 1)

KNOX
CO

CO

SALETYPE

control

03 Net 9/25

SA RINDYON TWP

11. TMAP[®]

PEORIA GO.

CAPITULO 1

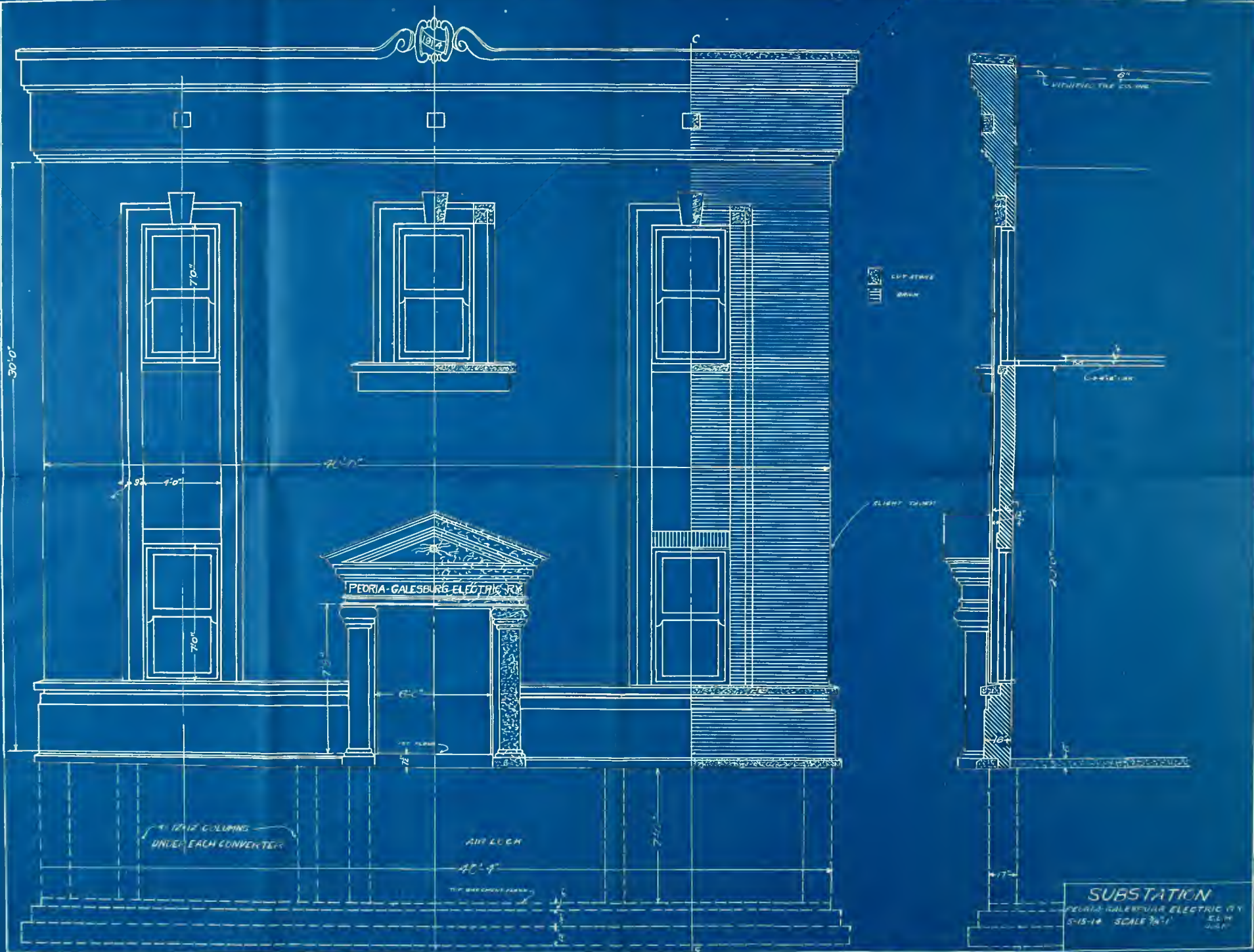
FAIRVIEW

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HANN

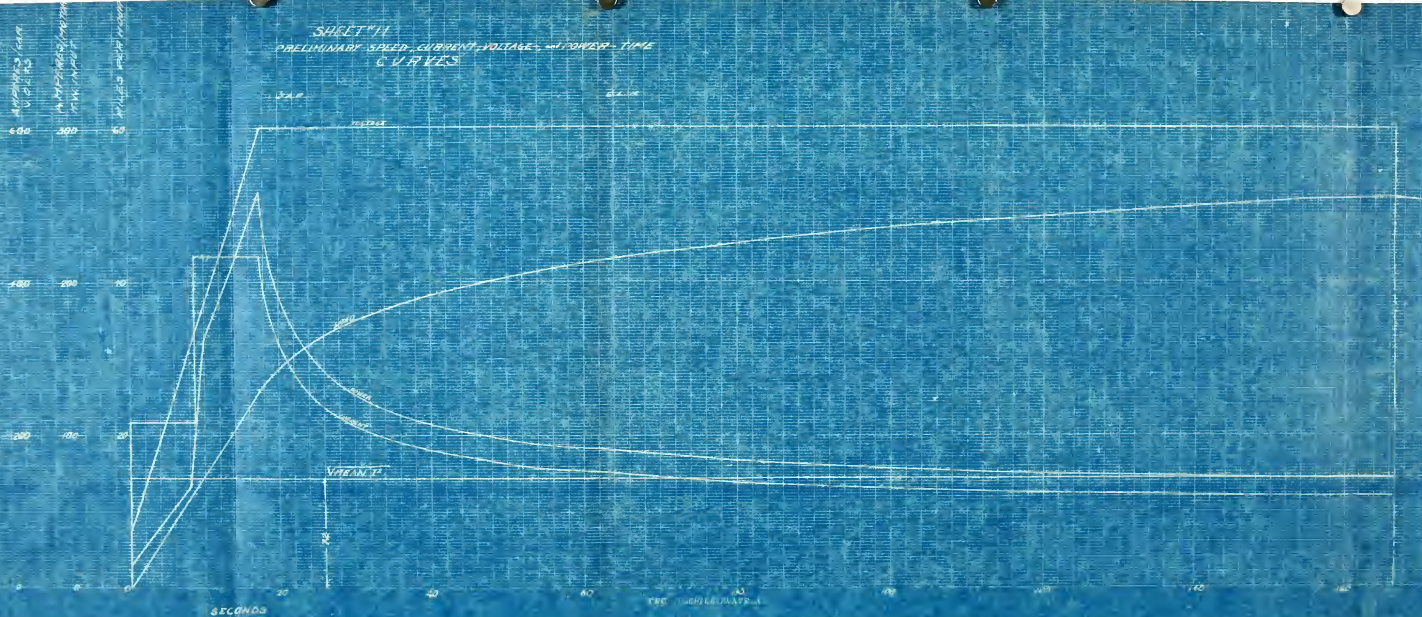
MAJNE

1. 1942-1943
2. 1943-1944
3. 1944-1945
4. 1945-1946
5. 1946-1947
6. 1947-1948
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256. 2197-2198
257. 2198-2199
258. 2199-2200
259. 2200-2201
260. 2201-2202
261. 2202-2203
262. 2203-2204
263. 2204-



FRONT ELEVATION

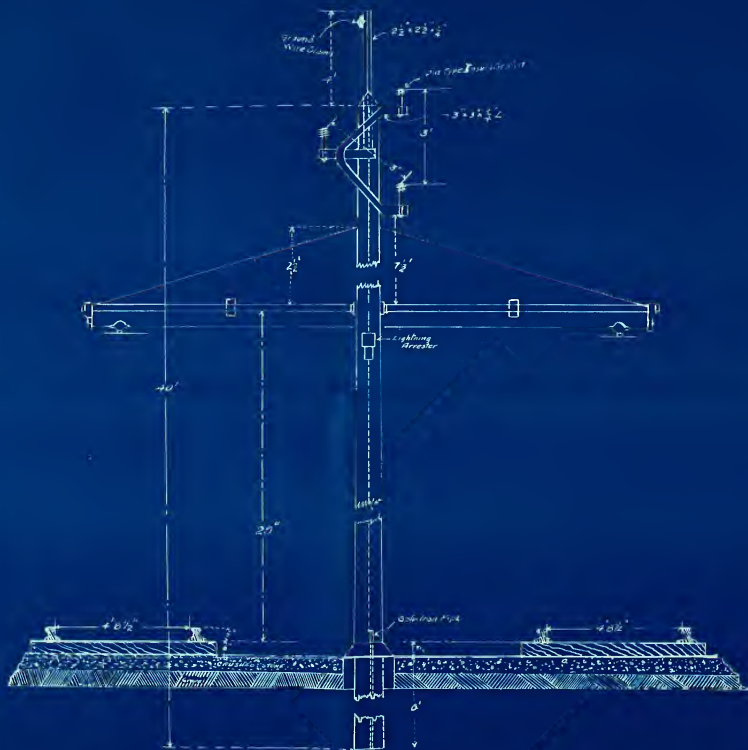
SHEET #11
 PRELIMINARY SPEED, CURRENT, VOLTAGE, & POWER - TIME
 CURVES



AVERAGE RUN
L = 19,500 FT

STOP

TSC PRO-ICE SCATE A

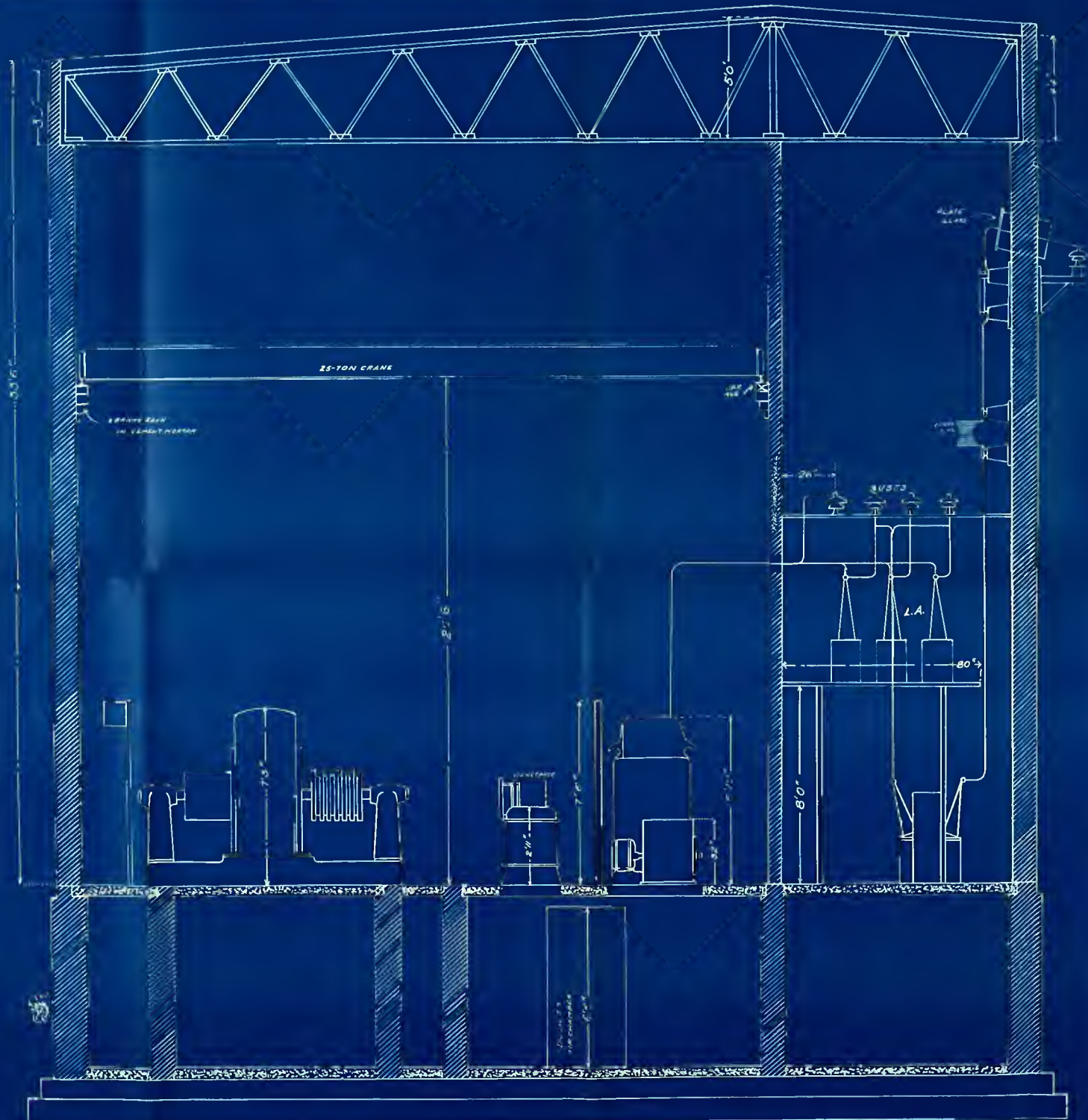


OVERHEAD CONSTRUCTION... CENTER POLES.

J. A. P.
E. L. W.

	1	3	5	7	9	11	13	15	17	19	21	23	25		2	4	6	8	10	12	14	16	18	20	22	24	26	
	A.M.								P.M.					Arrive	Leave	A.M.					P.M.							
PEORIA TERL.	12:47:45	11:17:45	9:47:45	8:47:45	7:47:45	6:47:45	5:47:45	4:47:45	2:47:45	12:47:45	10:47:45	8:47:45	7:47:45	PEORIA TERMINAL	5:00:00	6:00:00	7:00:00	8:00:00	9:00:00	11:00:00	1:00:00	3:00:00	5:00:00	6:00:00	7:00:00	8:00:00	9:00:00	11:00:00
	12:35:15	11:05:15	9:35:15	8:35:15	7:35:15	6:35:15	5:35:15	4:35:15	2:35:15	12:35:15	10:27:15	8:35:15	7:35:15	PEORIA LIMITS	5:12:30	6:12:30	7:12:30	8:12:30	9:12:30	11:12:30	1:12:30	3:12:30	5:12:30	6:12:30	7:12:30	8:12:30	9:42:30	11:12:30
DIRECTIONS	12:27:45	10:57:45	9:27:45	8:27:45	7:27:45	6:27:45	5:27:45	4:27:45	2:27:45	12:27:45	10:27:45	8:27:45	7:27:45	MAXWELL	5:20:45	6:20:45	7:20:45	8:20:45	9:20:45	11:20:45	1:20:45	3:20:45	5:20:45	6:20:45	7:20:45	8:20:45	9:50:45	11:20:45
	12:20:15	10:50:15	9:20:15	8:20:15	7:20:15	6:20:15	5:20:15	4:20:15	2:20:15	12:20:15	10:20:15	8:20:15	7:20:15	HANNA CITY	5:29:00	6:29:00	7:29:00	8:29:00	9:29:00	11:29:00	1:29:00	3:29:00	5:29:00	6:29:00	7:29:00	8:29:00	9:59:00	11:29:00
	12:16:15	10:46:15	9:16:15	8:16:15	7:16:15	6:16:15	5:16:15	4:16:15	2:16:15	12:16:15	10:16:15	8:16:15	7:16:15	EDEN	5:33:00	6:33:00	7:33:00	8:33:00	9:33:00	11:33:00	1:33:00	3:33:00	5:33:00	6:33:00	7:33:00	8:33:00	10:03:00	11:33:00
	12:10:45	10:40:45	9:10:45	8:10:45	7:10:45	6:10:45	5:10:45	4:10:45	2:10:45	12:10:45	10:10:45	8:10:45	7:10:45	THIVOLI	5:38:30	6:38:30	7:38:30	8:38:30	9:38:30	11:38:30	1:38:30	3:38:30	5:38:30	6:38:30	7:38:30	8:38:30	10:08:30	11:38:00
	12:06:15	10:36:15	9:06:15	8:06:15	7:06:15	6:06:15	5:06:15	4:06:15	2:06:15	12:06:15	10:06:15	8:06:15	7:06:15	CRAMERS	5:44:00	6:44:00	7:44:00	8:44:00	9:44:00	11:44:00	1:44:00	3:44:00	5:44:00	6:44:00	7:44:00	8:44:00	10:14:00	11:44:00
BOTH	11:57:45	10:27:45	8:57:45	7:57:45	6:57:45	5:57:45	4:57:45	3:57:45	1:57:45	11:57:45	9:57:45	7:57:45	6:57:45	FARMINGTON	5:52:30	6:52:30	7:52:30	8:52:30	9:52:30	11:52:30	1:52:30	3:52:30	5:52:30	6:52:30	7:52:30	8:52:30	10:22:30	11:52:00
	11:47:00	10:17:00	8:47:00	7:47:00	6:47:00	5:47:00	4:47:00	3:47:00	1:47:00	11:47:00	9:47:00	7:47:00	6:47:00	UNIONTOWN	6:03:30	7:03:30	8:03:30	9:03:30	10:03:30	12:03:30	2:03:30	4:03:30	6:03:30	7:03:30	8:03:30	9:03:30	10:33:30	12:03:30
LOCAL	11:37:45	10:07:45	8:37:45	7:37:45	6:37:45	5:37:45	4:37:45	3:37:45	1:37:45	11:37:45	9:37:45	7:37:45	6:37:45	MAQUON	6:12:45	7:12:45	8:12:45	9:12:45	10:12:45	12:12:45	2:12:45	4:12:45	6:12:45	7:12:45	8:12:45	9:12:45	10:42:45	11:12:45
	11:29:15	9:59:15	8:29:15	7:29:15	6:29:15	5:29:15	4:29:15	3:29:15	1:29:15	11:29:15	9:29:15	7:29:15	6:29:15	GILSON	6:20:45	7:20:45	8:20:45	9:20:45	10:20:45	12:20:45	2:20:45	4:20:45	6:20:45	7:20:45	8:20:45	9:20:45	10:50:45	11:20:45
CARS	11:19:00	9:49:00	8:19:00	7:19:00	6:19:00	5:19:00	4:19:00	3:19:00	1:19:00	11:19:00	9:19:00	7:19:00	6:19:00	KNOXVILLE	6:31:15	7:31:15	8:31:15	9:31:15	10:31:15	12:31:15	2:31:15	4:31:15	6:31:15	7:31:15	8:31:15	9:31:15	11:01:15	11:31:15
	11:13:00	9:43:00	8:13:00	7:13:00	6:13:00	5:13:00	4:13:00	3:13:00	1:13:00	11:13:00	9:13:00	7:13:00	6:13:00	GALESBURG	6:37:15	7:37:15	8:37:15	9:37:15	10:37:15	12:37:15	2:37:15	4:37:15	6:37:15	7:37:15	8:37:15	9:37:15	11:07:15	12:37:15
ALL	11:07:30	9:37:30	8:07:30	7:07:30	6:07:30	5:07:30	4:07:30	3:07:30	1:07:30	11:07:30	9:07:30	7:07:30	6:07:30	GALESBURG LIM.	6:42:30	7:42:30	8:42:30	9:42:30	10:42:30	12:42:30	2:42:30	4:42:30	6:42:30	7:42:30	8:42:30	9:42:30	11:12:30	12:42:30
	11:00:00	9:30:00	8:00:00	7:00:00	6:00:00	5:00:00	4:00:00	3:00:00	1:00:00	11:00:00	9:00:00	7:00:00	6:00:00	GALESBURG TERL.	6:50:00	7:50:00	8:50:00	9:50:00	10:50:00	12:50:00	2:50:00	4:50:00	6:50:00	7:50:00	8:50:00	9:50:00	11:20:00	12:50:00
									P.M.					Leave	Arrive					P.M.								

SUBSTATION
PEORIA-GALESBURG ELECTRIC RY.
5-15-14 SCALE $\frac{3}{8}$ " = 1' E. M.
J. A. R.



SECTIONAL ELEVATION

SUBSTATION
 VICTOR-GALBRAITH ELECTRIC CO.
 3115-18 SCALE 3/8"=1' J.A.S.
 1944

33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

O/L SWITCH

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

10. 33000" a.c. system

WIRING DIAGRAM

SUBSTATION
PEDRIA-GALESBURG ELECTRIC CO.
5-15-19
J.A.R.
E.S.H.

SHEET 10

7/0

TOTAL SUBSTATION
LOAD DIAGRAM
R-G CRY
TLM
PAP

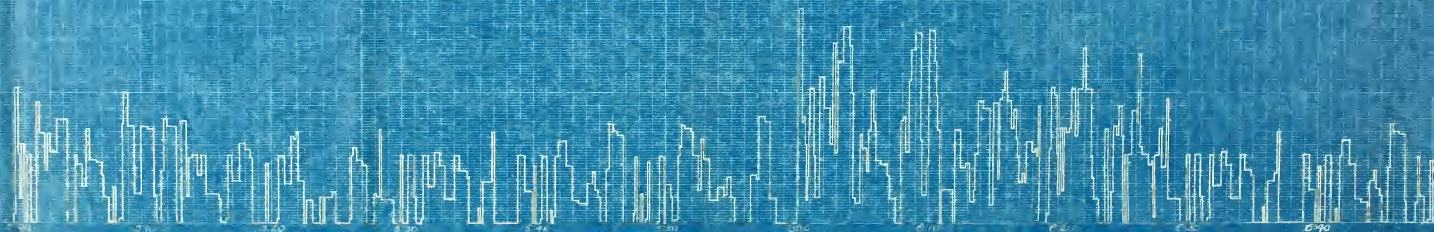
KW

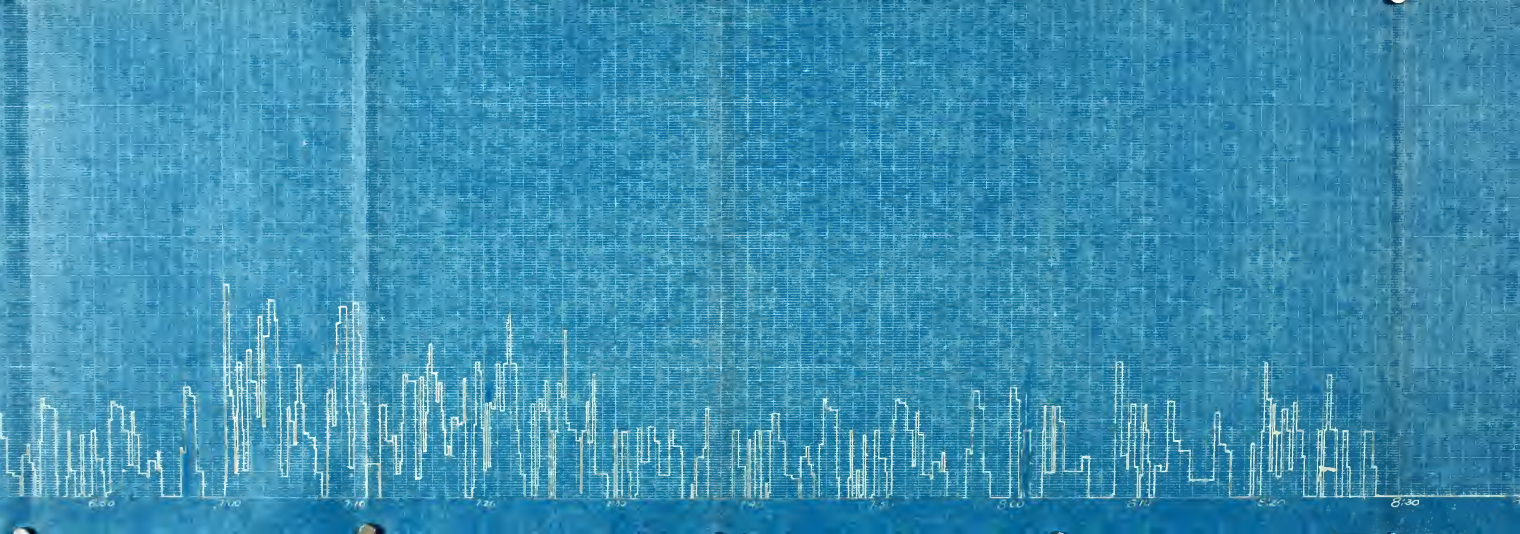
7000

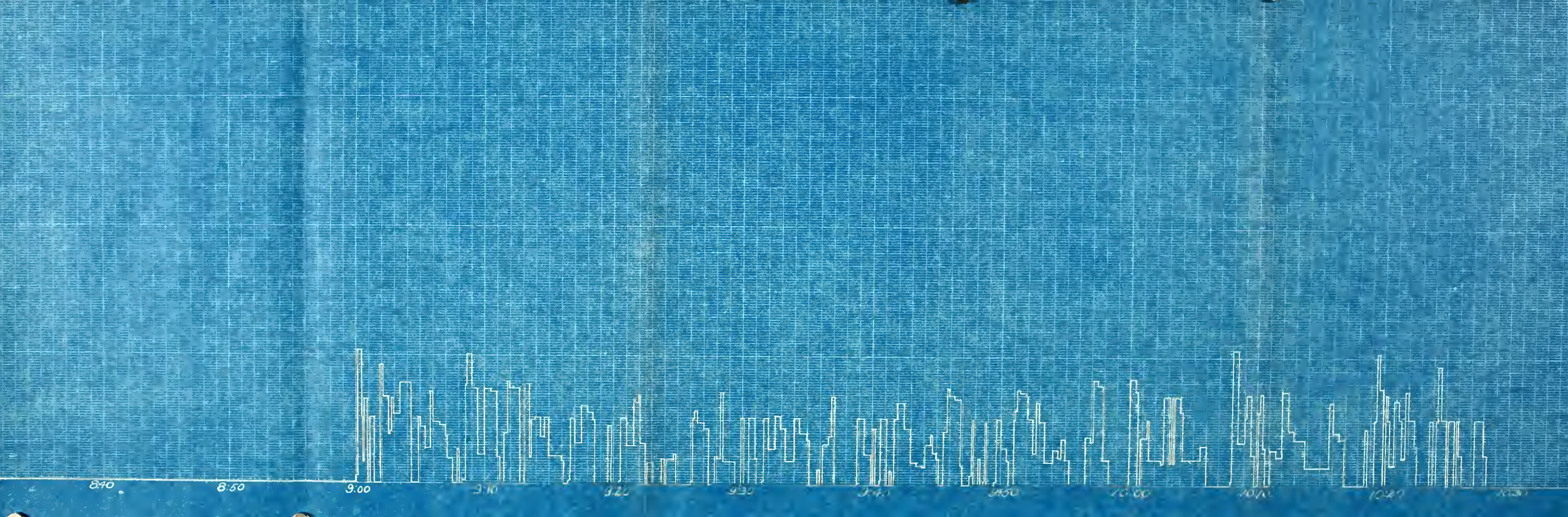
500

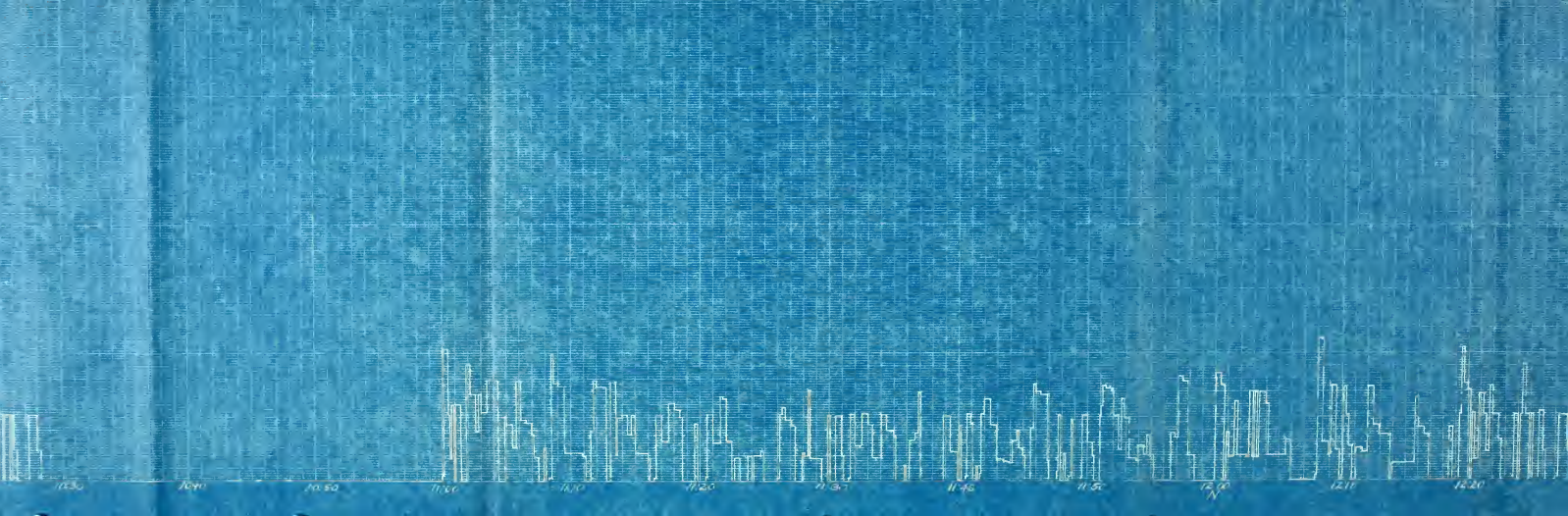
400

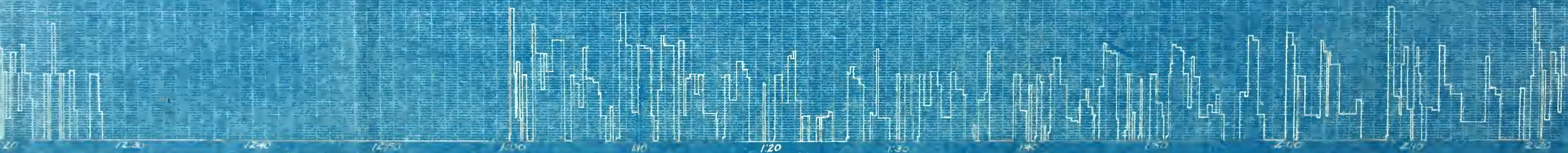
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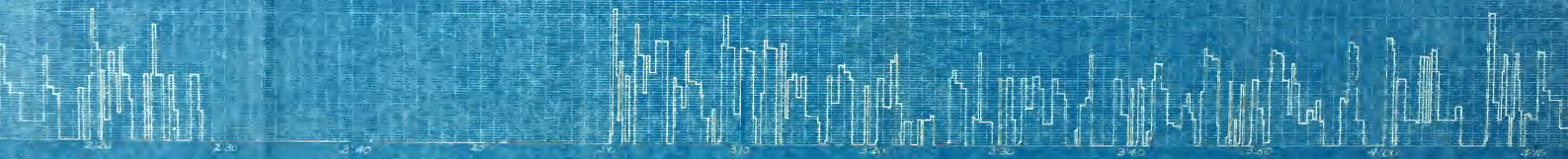


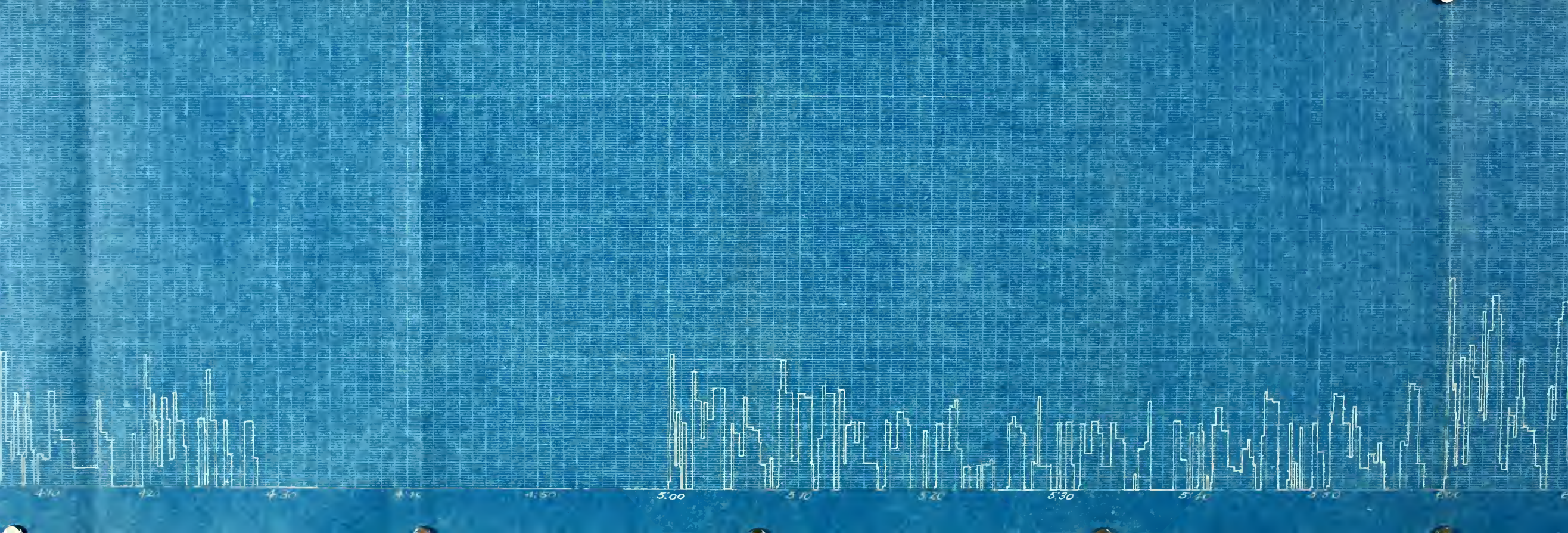


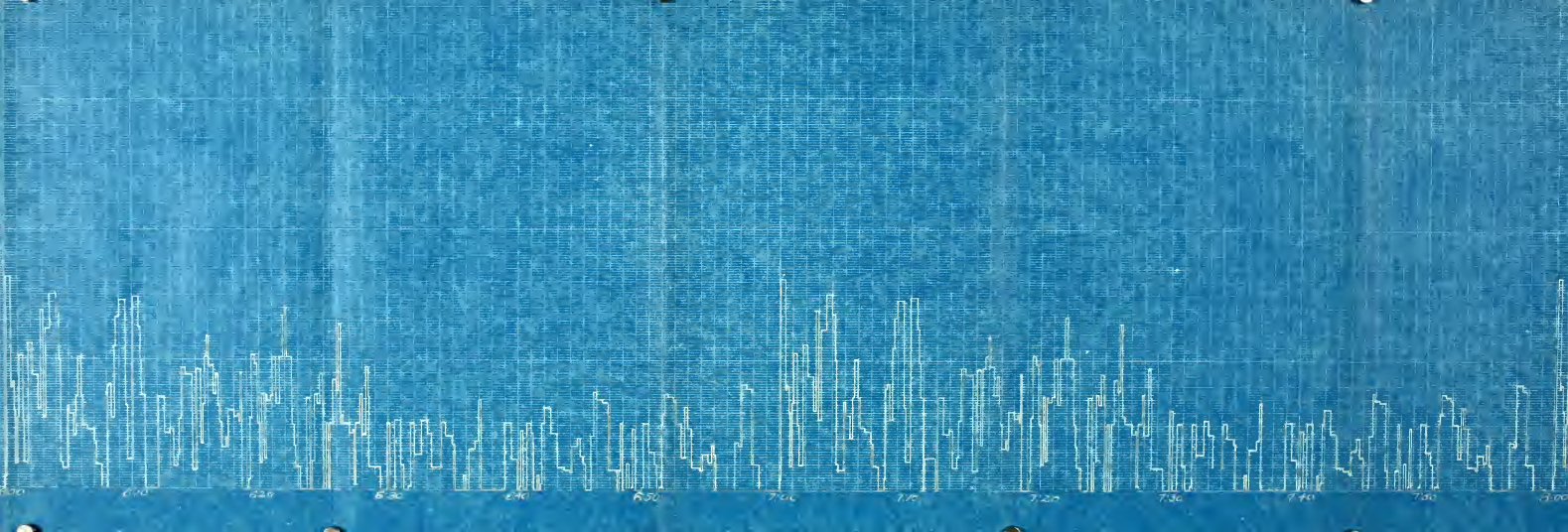


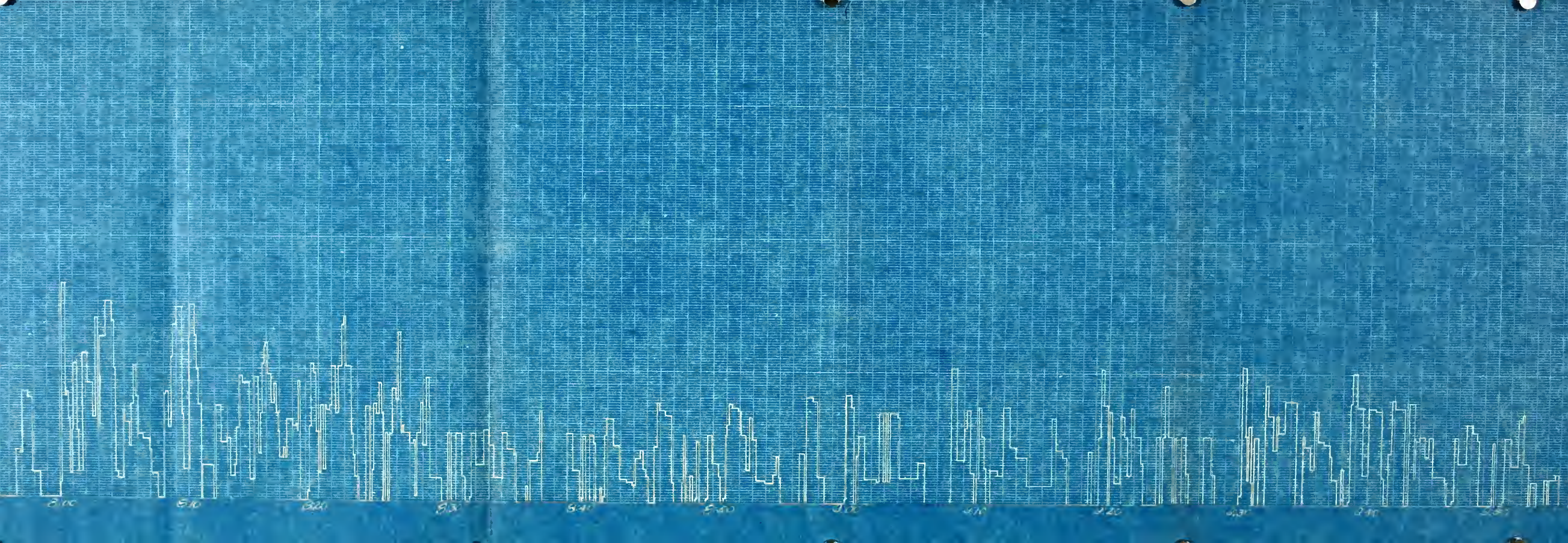


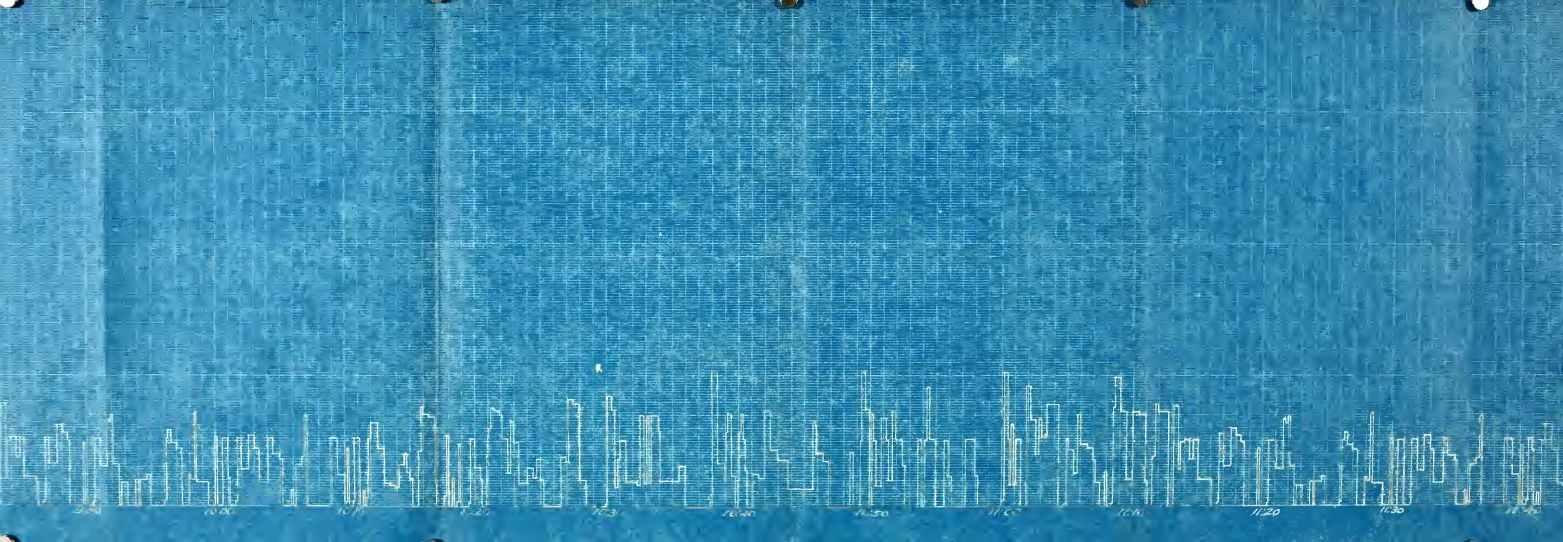












9:50

10:00

10:10

10:20

10:30

10:40

10:50

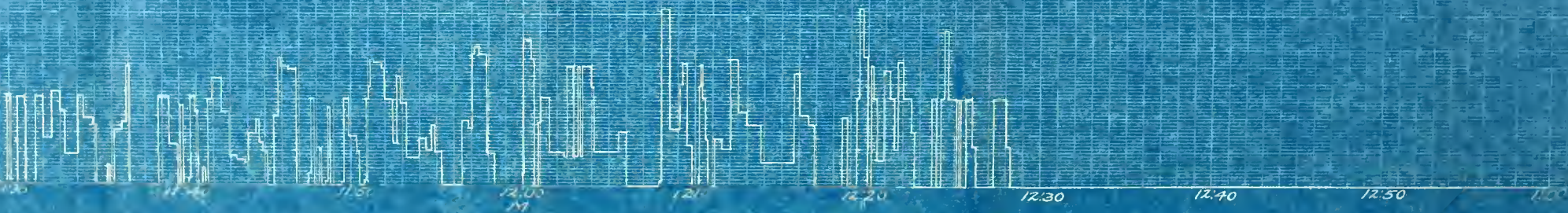
11:00

11:10

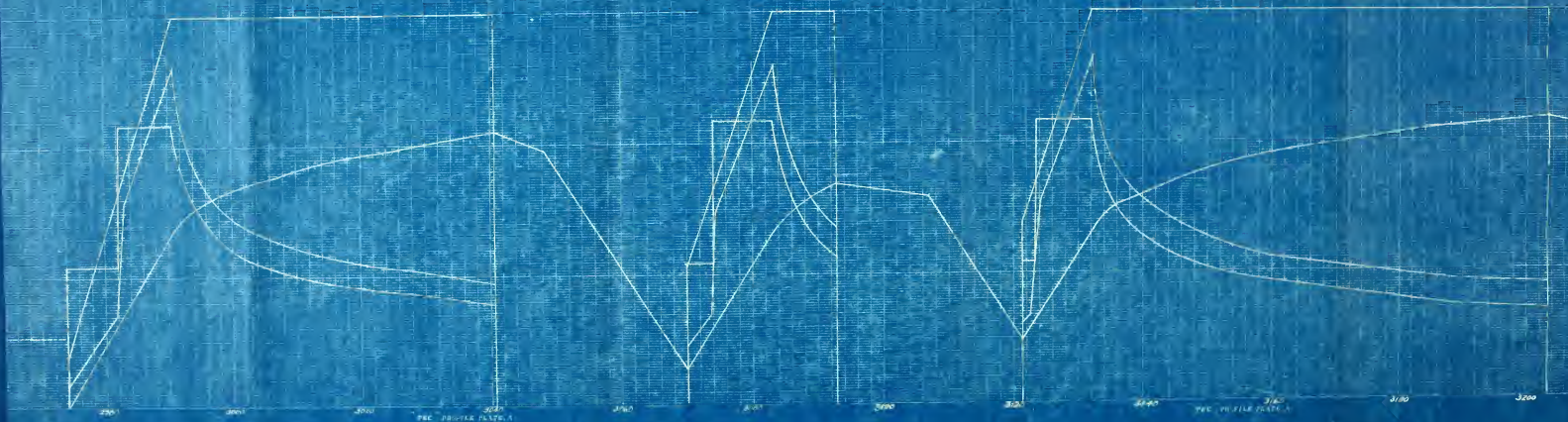
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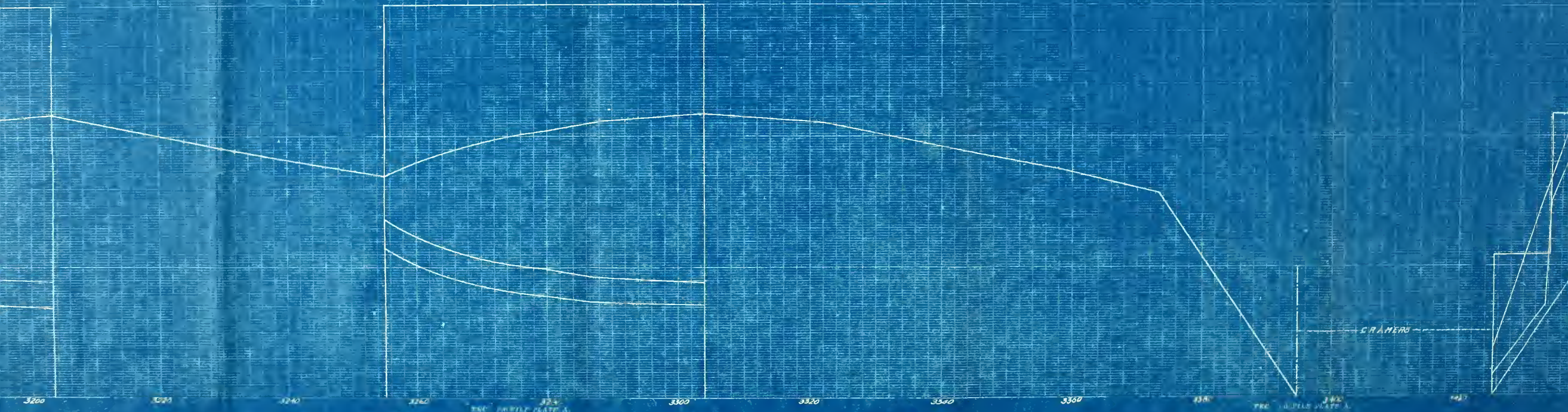
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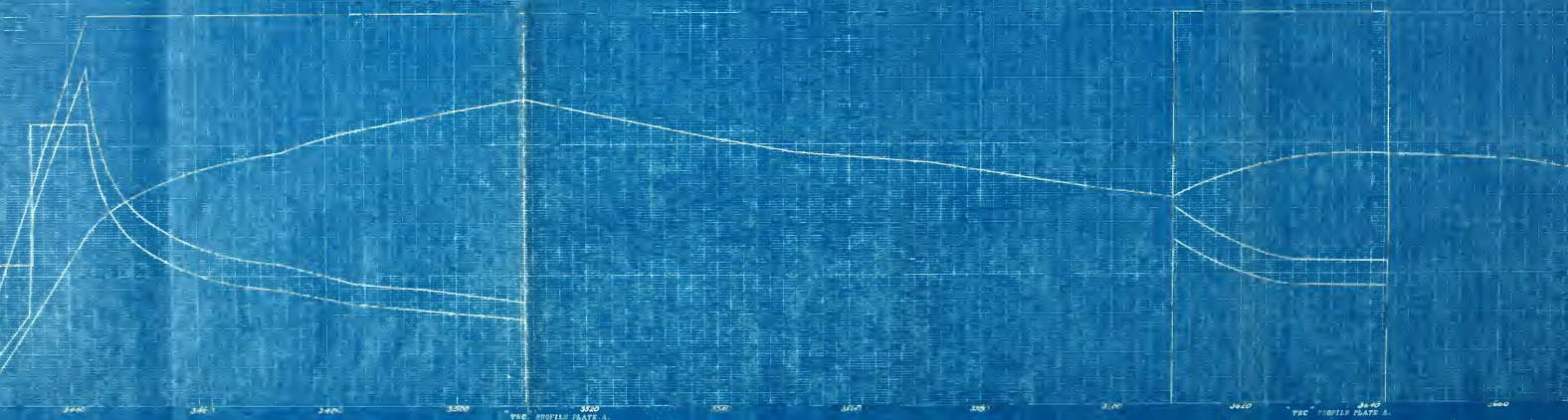
11:45

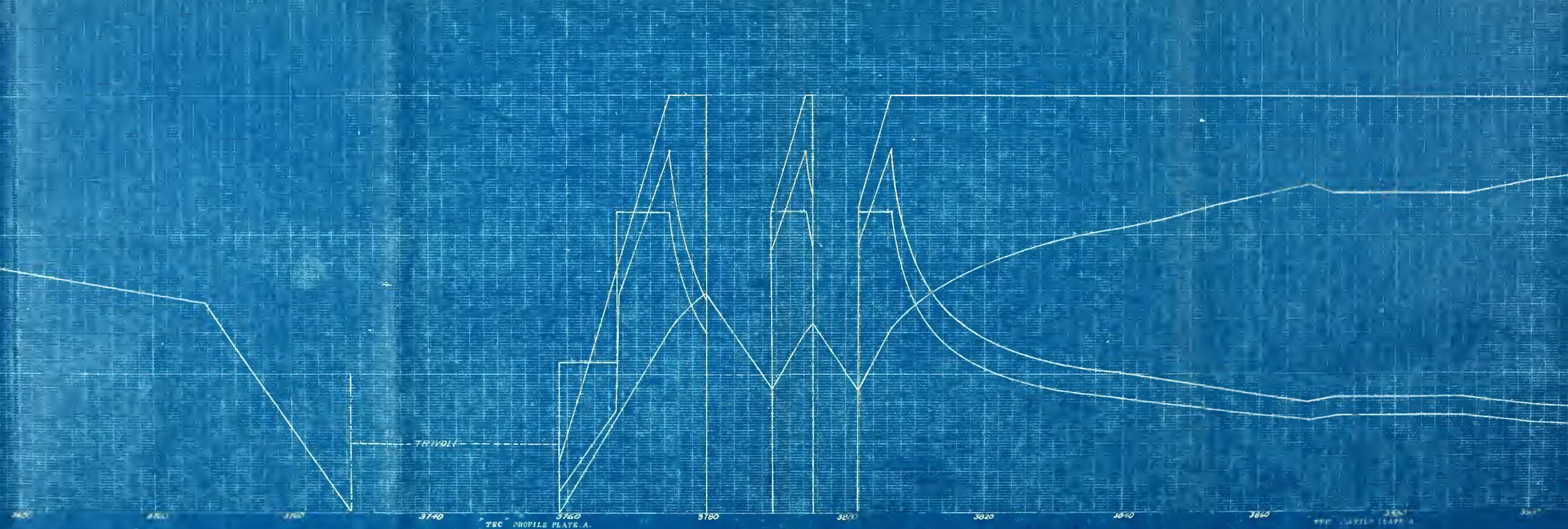


RECHINGTON



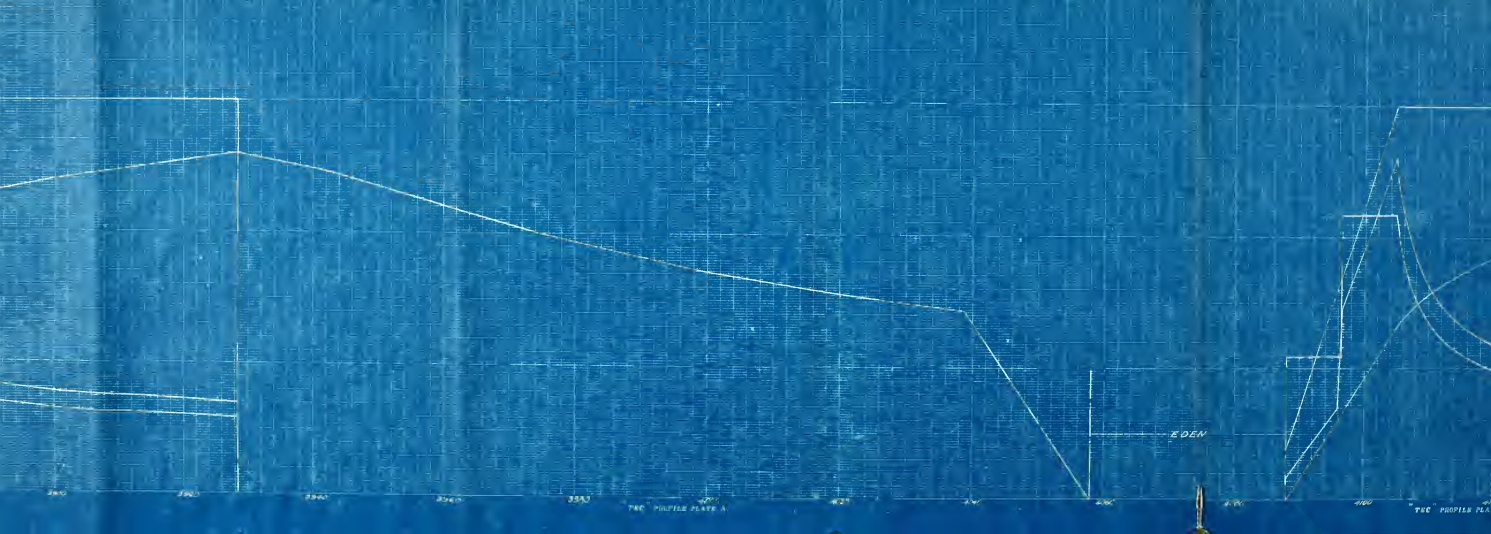


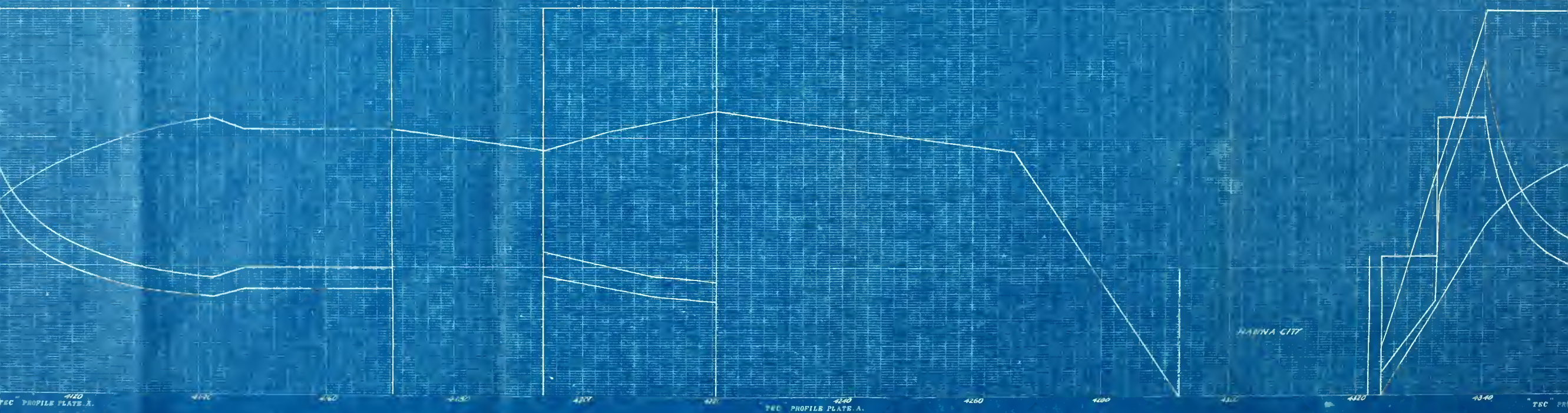




"TEC" PROFILE PLATE A.

"TEC" PROFILE PLATE A.

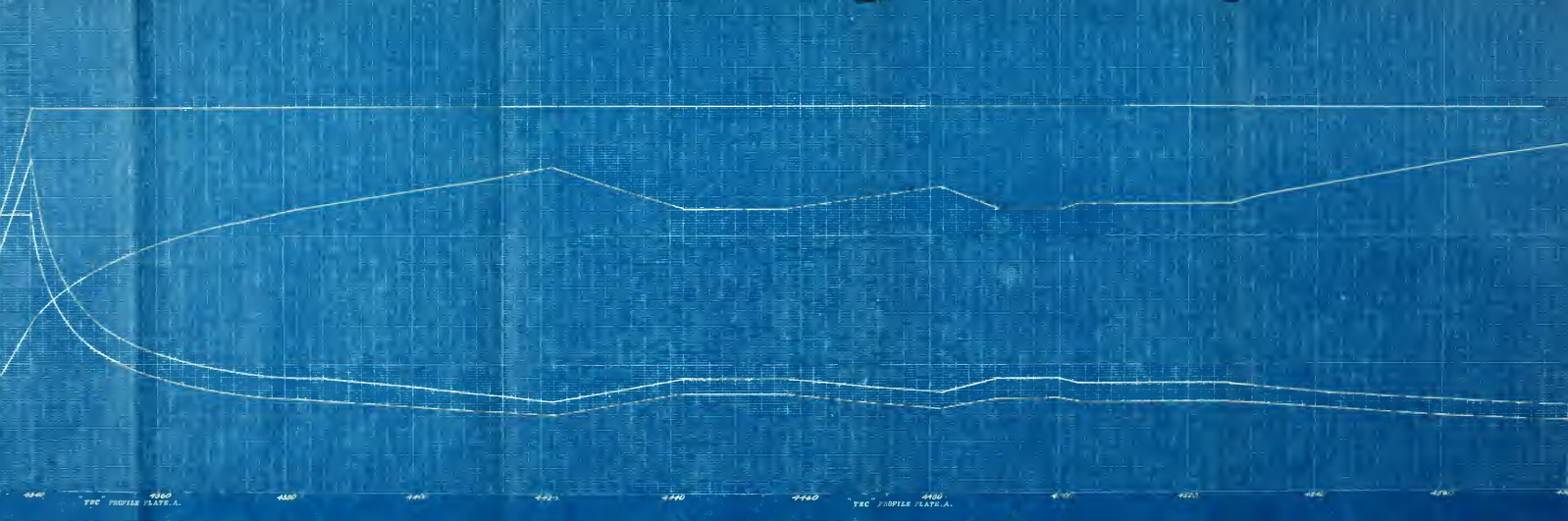


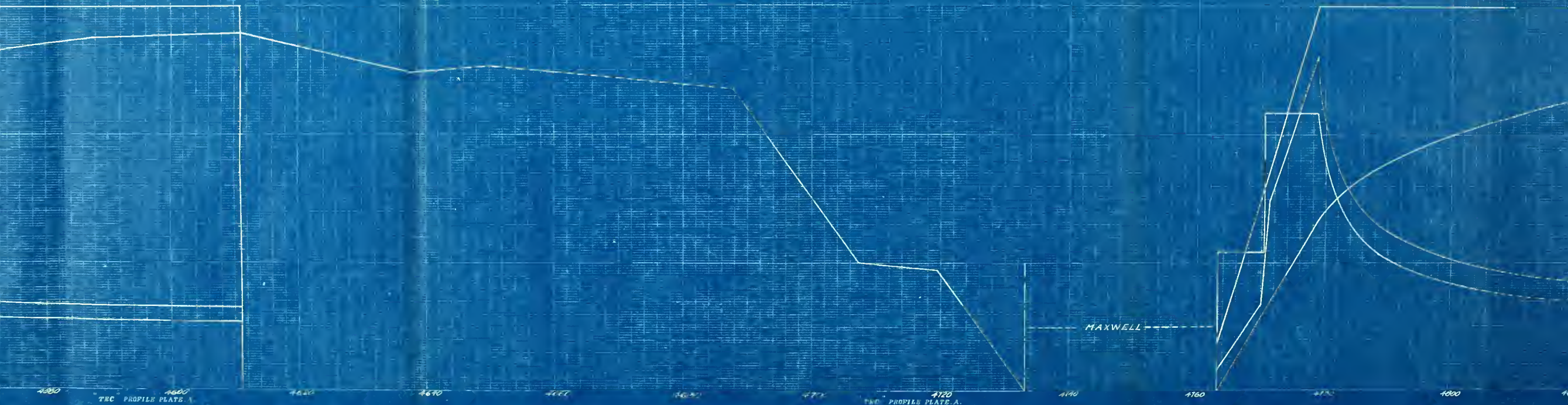


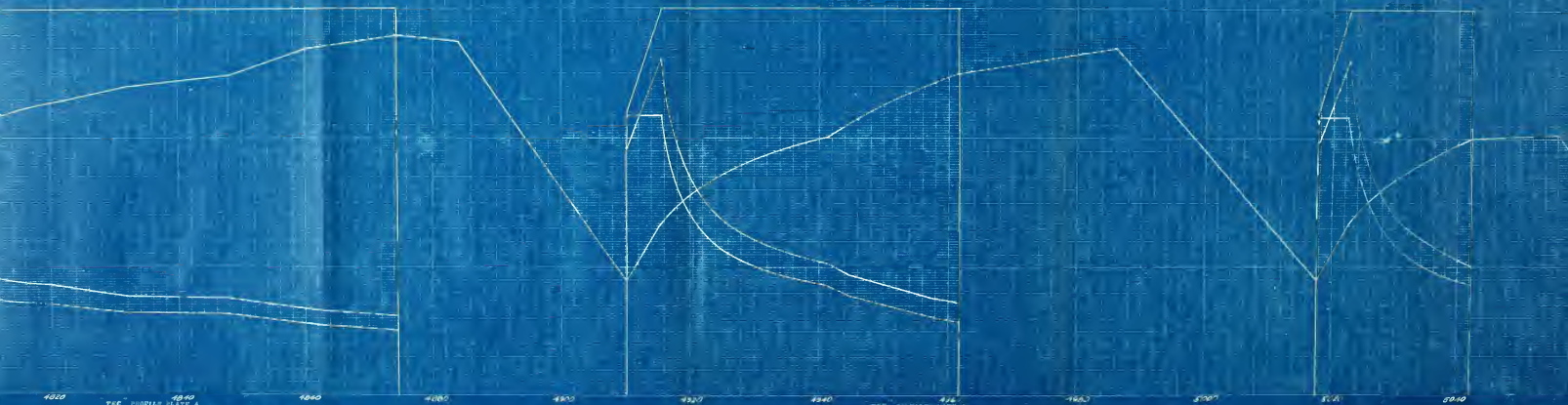
4120
TFC PROFILE PLATE A.

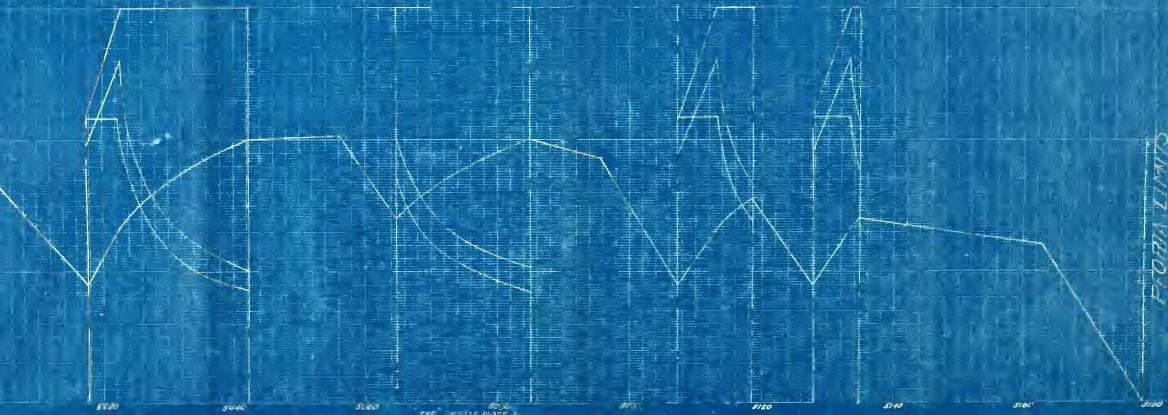
4240
TFC PROFILE PLATE A.

4340
TFC PROFILE PLATE A.









5740
5745
5750

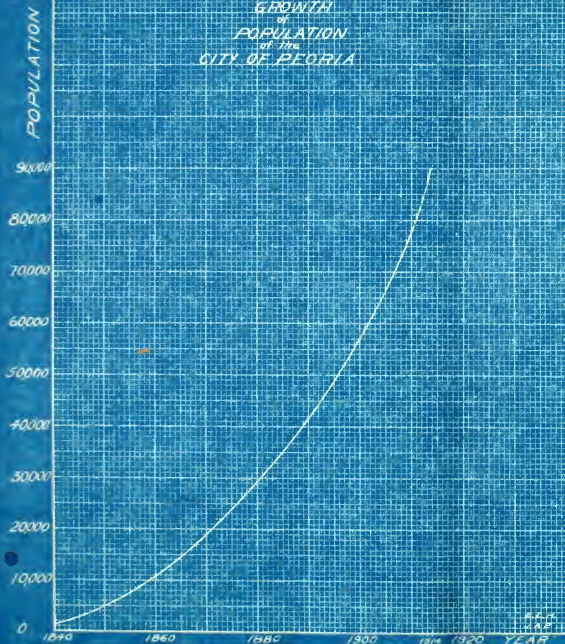
FLORA LIMITS

5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800

5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800

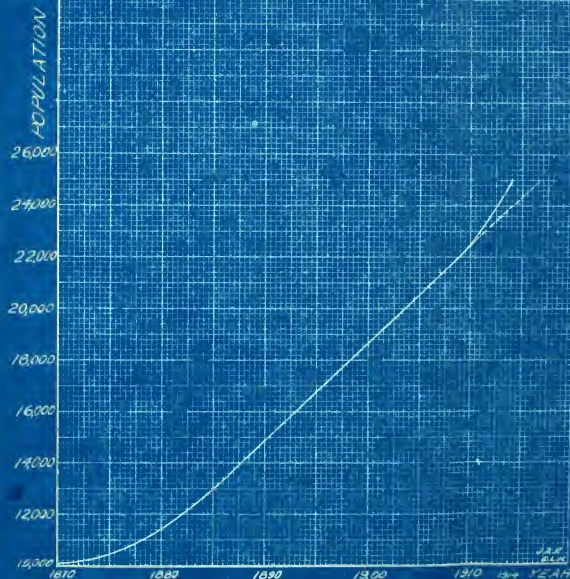
SHEET #2

GROWTH
OF
POPULATION
of the
CITY OF PEORIA



SHEET #3

GROWTH
OF
POPULATION
of the
CITY OF GALESBURG



SHEET #4



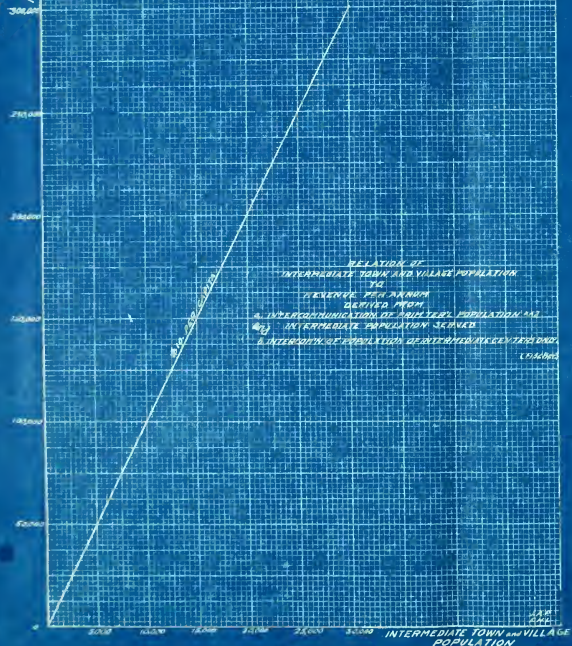
ROUTE IN PEORIA.
LENGTH 3.17 MILES SCALE 1"=2000'

SHEET #5



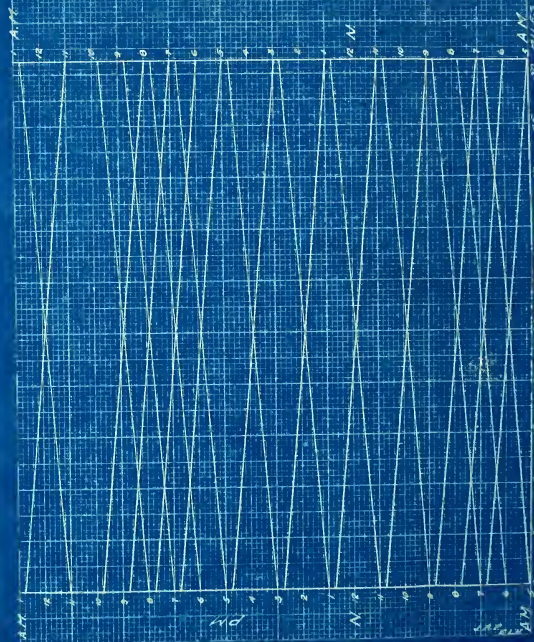
ROUTE IN GALESBURG
LENGTH 1.53 MILES SCALE 1"=1000'

SHEET "6"



SHEET "7"

PRELIMINARY SCHEDULE



SHEET #9

TRAIN RESISTANCE

SINGLE CAR 45 TON

MILES PER HOUR

70

60

50

40

30

20

10

0

5 10 15 20 25 30 35 40 POUNDS/TON

W.A.P.
H.K.

FREEMAN AND BROS.

SHEET #10

2400

2200

2000

1800

1600

1400

1200

1000

800

600

400

200

0

AMPERES

50

100

150

200

250

EFFICIENCY

100

96

92

88

84

80

76

72

68

64

60

56

52

48

44

40

36

32

28

24

20

16

12

8

4

SPEED

MOTOR CHARACTERISTICS

G.E. 60 A-8

125 H.P. at 208 rpm

GEAR RATIO 2.07

